Sustainable Athletic Fields:
Turf Management and Artificial Turf Options

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Driven to Discover℠

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The contents of this report represent the views of the authors, and do not reflect those of RCP, CURA, the Regents of the University of Minnesota, or the City of Brooklyn Park.

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Group 1 Report

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Turfgrass recommendation for Brooklyn Park

Brooklyn Park is the 6th largest city in Minnesota and is located next to the Twin-Cities. It has a population of almost 80,000. To discover possible improvements for urban park systems, which can potentially provide the citizens a better living experience in this unique and multicultural city, CURA along with the University of Minnesota has started the Resilience Communities Project (RCP), which aims on making sustainable and resilient communities. Our focus is on improving one of the 35 A-leveled athletic fields named Noble Sports Park, which is involved in the large recreation and park system.

Noble Sports Park is away from downtown, located along highway 610. It currently has 6 soccer fields, 4 softball fields, 1 baseball field, tennis courts and basketball courts. Around the park are three parking lots and an elementary school. The demographics have changed and now includes a high ratio of people with diverse cultural background and an increasing population rate. Moreover, for reasons of diversity and the change of trends, various sports are played requiring the use of the park such as soccer, lacrosse, and football among others. The users of the park are small groups, sports clubs/associations, schools, and individuals from the public. Combining the information we've collected from assigned soccer fields and data offered from the manager of the parks we hope to fix some issues. The problems that we need to consider are: wear, compaction and water issues caused by increasing use. Two possible solutions exist, renovate and implement different management protocol for the existing turf, or install a synthetic turf field.

To determine whether or not a synthetic turf should be installed at the noble park fields, a visual assessment of the field's current conditions was needed. Upon arriving, it was easy to see which fields were used the most. Fields 1 and 2 had sustained the most damage up to this point in the season. The damage was extensive around the goal areas and up to the point of center field. This was confirmed by the Clegg monitor producing a value over the safe number at several locations in both fields. Looking at Field 2, you can see from the visual provided below, there were several different readings across the field. The north side of the field's Clegg readings were the highest in the goal area which was 281, and the center of the field read at 261. Both of these readings are higher than the recommended compaction levels

Field 1					Field 2			
North Side of Field	L	C	R		North Side of Field	L	C	R
G	129	209	148		G	101	281	116
M	122	185	177		M	148	198	133
C	111	148	201		C	163	261	155
South Side of Field	L	C	R		South Side of Field	L	C	R
C	96	216	205		C	122	222	163
M	96	177	135		M	135	185	166
G	111	172	113		G	109	163	100

L=Left Side of Field, **C**=Center Field, **R**=Right Side of Field
G=Goal Line, **M**=Middle Side of Field

thought to be safe for people to participate in activities like soccer and football. The edges of the field were lightly worn and the corners of the field to the right and left of the goal had the lowest readings, as displayed by the diagram. Fields 3 and 4 were less worn than fields 1 and 2 and fields 5 and 6 exhibited the least amount of wear. However each field had near identical patterns of wear. Along with the wear, other problems were noted upon arriving. Field 2 had a center that was concave which could potentially cause drainage issues with water pooling in the middle of the field. Field 1 was not concave in this way rather it sloped off to the west which would likely cause a more successfully drained field.

The grass species were similar throughout all of the fields. Predominantly Kentucky bluegrass was present. This species is generally the most popular in many turf settings, however it is considered one of the grasses requiring the most care throughout the year to keep a healthy stand. In addition to Kentucky bluegrass, perennial ryegrass was overseeded in areas seasonally to combat wear patterns.

Tall fescue was present as a weedy species in bulky patches throughout each field and causes concern for aesthetics and injuries as well due to its clumpy habit in the weed form of this species. Annual bluegrass was present in patches throughout each field as well, causing light green patches in the dark green Kentucky bluegrass stand. Beyond aesthetic differences in color between the annual bluegrass and species used in the field, mid-summer conditions can lead to browning of annual bluegrass that is undesirable for a field manager. Broadleaf plantain was also discovered in heavily worn areas of field 1 and 2 and was the most prevalent broadleaf weed issue.

Another concern was the health of the soil. We pulled a sample bag of soil from each field and they are all very similar in their characteristics. The texture of the soil was coarse through each field. This means that water infiltration is likely not of large concern, but could mean that water is leaving the root zone before the plant can use it effectively. The soil report for each field listed a relatively high pH which was around 7.8. This is generally too alkaline for most plants as nutrients become less available to them at a pH of this level. Optimal pH levels would be around 6.5 to 7. Soil potassium and nitrogen were also low in similar amounts for each field, however phosphorus was very high.

The challenges of this site are quite clear. As it is a public park, it can be difficult to have unscheduled games spread out throughout the whole park because players will likely choose the closest field to them, which causes extra use on field 1 and 2. However even scheduled events make fields 1 and 2 busier receiving over 70 more reservations per year than any of the other fields in 2016. However, just 5 years ago this was not the case, in 2011 and 2012 each field received almost identical reservations in the respective years. There was an influx of extra reservations but rather than the reservations being spread out evenly between the 6 fields, the extra workload was mainly only being experienced by fields 1 and 2. After a quick conversation with Mike Hoag, manager of Noble Park, it became clear that the extra reservations came from a football program having night practices and needed lit fields. This caused these fields to become severely overworked.

We believe that keeping the regular grass fields at Noble Park would be the best option for the city of Brooklyn Park. An artificial turf field may draw extra attention due to the excitement about a synthetic turf field and would cause problems with scheduling. Because of the increased attention this field would sustain, and with the minimal ability to purchase all the specialized equipment needed for maintenance, the turf will likely not be safe and aesthetically pleasing for long. A recommendation of artificial turf would be troublesome in budgeting and maintenance requirements when compared to natural turf. Maintenance is required often and is labor intensive, and requires specialized equipment. Rain infiltration is significantly affected by debris accumulation and will thus require regular decontamination (Prateek *et. al*, 2016.) Under maintenance will result in severe accumulation of debris after only a number of years which would cause drainage issues. Brushing fibers is also required in aiding resilience. The decompaction process must be undertaken 3 to 4 times per year involving specialized equipment as well as replacement of crumb rubber. Lost crumb rubber is believed by some to be the main cause of surface hardness rather than compaction. (Serensits and McNitt, 2014.) A daily safety inspection would be recommended to detect tears and litter removal. This would require specialized knowledge and potentially costs in additional training. Weekly brushing to level infill would also be recommended requiring even more labor and machinery costs. Cleaning is recommended monthly as well. Given the labor-intensive nature of maintaining a safe artificial turf, the additional machinery costs, and initial cost of installation, artificial turf does not appear to be an economic or efficient solution to any issues at Noble Sports Park.

Recommended Maintenance Regimen for Artificial Turf

- Daily - Safety inspection, check surface and seams for damage/failure, pick litter.
- Weekly – Drag brush to level infill and lift fibres 1 or 2 times, can be done in-house with basic machinery and drag mats or specialist static brushes (e.g. of flexible stiffness). Check and top up infill at high wear areas.
- Monthly - Rotary (power) brush and clean the surface, pick up fibre debris, detritus, agitate infill. For 2G sand filled surfaces relatively shallow depth, 2-3mm (if very wet weather infill clumps and can pick up too much infill). For 3G rubber crumb can adjust to brush a little deeper (less resistance is encountered). Requires specialist equipment. Chemical or vegetation treatment of the surface for any weed, moss or algae growth.
- Yearly - At least 3-4 times per year on 3G, a decompaction to agitate the infill combined with power-sweeping to vacuum off detritus. Check and top up infills. For 2G a deeper power bush (termed 'revitalisation') can remove the top 10 mm of sand infill, separate out 'contamination' and replace the infill, with specialist equipment. Annually detailed inspection of the site and testing to evaluate carpet wear, infill contamination, key play performance tests (sport dependent but minimum of FR, VBR, infill depth and free pile height/Ball roll). Every 5 years or so, if experiencing poor drainage of a 2G AGP, consider infill removal and replacement (termed 'rejuvenation').

Source: *Maintenance regimen of artificial turf (Prateek, et. al, 2016.)*

A comprehensive study conducted by the Government of Western Australia, showed that the lifetime costs of an artificial turf field greatly exceed that of a natural grass field. For a 25 year cycle of fields utilized for soccer, the study estimated total costs of natural grass, including installation and maintenance, at $1,004,917 versus an artificial field costing $2,517,500. Beyond the total capital investment initially and over the lifetime of the project being higher purely for artificial field ownership, the operating costs are not substantially different in order to justify the price. A community level field will have operating costs of $27,250 a year for natural grass and $25,000 for artificial turf.

Table 1: Turf Species Performance

		2008-2009 quality (April-Oct.)[†]							
Cultivar or selection	Spp.[‡]	IA[§]	KS	MI	MN	NE	OH	IL	WI
Falcon IV	TF	5.0	7.2	6.5	7.1	7.6	5.4	7.1	6.0
Rebel Exeda	TF	5.3	7.2	6.2	6.9	7.2	5.8	7.2	5.1
Jamestown II	CF	5.7	5.9	5.9	7.0	6.6	5.4	6.0	6.4
Barlexas II	TF	3.6	7.4	6.2	7.1	7.7	5.3	6.3	5.1
Culumbra II	CF	5.6	5.9	6.1	6.9	5.9	5.2	6.6	6.4
Intrigue	CF	5.6	6.5	6.0	6.9	6.4	5.4	6.4	5.0
SR 3150	HF	6.6	6.3	5.2	7.9	6.1	6.5	2.7	5.8
Revere	CB	5.7	4.8	5.5	5.7	5.8	4.6	7.0	5.9
Reliant IV	HF	6.2	6.9	5.0	7.1	5.9	6.3	3.1	4.3
Barking	CB	5.5	4.7	5.5	5.6	6.5	4.8	6.7	5.4
Predator	HF	6.2	6.4	4.8	7.3	5.9	6.3	2.7	3.3
Firefly	HF	5.8	6.2	3.8	6.7	5.4	5.6	3.1	4.2
SRK	PJ	5.7	6.2	4.2	6.9	5.8	5.4	2.1	4.3
SR 6000	TH	4.3	6.6	3.7	5.8	5.7	4.1	3.9	5.1
Thermal Blue	HB	3.9	4.9	4.8	6.4	6.0	4.9	4.6	3.5
Azay	SF	5.9	5.4	3.2	6.4	5.2	6.0	2.3	4.0
Diva	KB	3.4	5.6	4.5	6.3	6.5	4.5	3.4	4.0
Barleria	PJ	5.4	6.3	4.1	6.7	5.9	4.5	1.8	3.0
Barok	SF	5.8	5.3	2.8	5.4	5.0	4.8	3.3	4.6
Barcampsia	TH	3.6	5.5	3.7	6.7	6.0	3.3	3.8	4.2
Azure	SF	4.9	5.9	2.9	6.1	5.2	5.4	2.3	3.6
Bandera	HB	3.6	4.6	4.1	6.2	5.9	4.0	3.0	3.2
Dura Blue	HB	4.3	4.3	3.8	5.6	6.1	2.8	2.4	2.8
ShadeChamp	TH	3.7	4.7	2.7	5.9	5.3	2.3	1.9	2.6
Spike	IB	3.5	2.4	2.7	3.4	3.4	2.7	2.5	2.2
LSD[#]		0.7	1.0	0.8	0.6	1.1	0.9	1.2	1.6

Average of multiple quality ratings in 2008 and 2009 at each location (1–9 scale, where 9 = best turfgrass quality). Quality components included plot cover, uniformity, color, density and freedom from disease and insect damage.

[‡]Species: TF = tall fescue; CF = Chewings fescue; SF = sheep fescue; HF = hard fescue; CB = colonial bentgrass; PJ = prairie junegrass; HB = Kentucky bluegrass × Texas bluegrass hybrid; TH = tufted hairgrass; IB = Idaho bentgrass.

` We believe that it would be in the best interest for the City of Brooklyn Park to keep the fields as turf grass instead of synthetic grass. Although the synthetic grass would be nice and attract more people to play on the field, the overall maintenance of the field would be greater and more expensive compared to the existing turf grass. Artificial turfs that take a lot of use and generally do not last as long as expected. If you were to maintain the existing fields, overseeding, aerating multiple times a year, top dressing the fields, as well as completely renovating the field every 4-5 years would be cheaper and would allow for multiple fields to be addressed rather than just one artificial synthetic turf field that needs maintenance regularly. Utilizing the sources that we have from lectures and field trips, it would be sufficient to say that a turf grass field is the direction that we want to steer Brooklyn Park's Noble Play Fields.

Tall fescue is an intriguing prospect for reducing maintenance, irrigation, and fertilization and has better heat tolerance in the summer months than perennial ryegrass and Kentucky bluegrass. Watkins et al. (2014) performed low input cultivar performance tests on several grass species and in several states.

The tests consisted of two years of data and after establishment no irrigation or fertilizer was supplemented to the grass stand. The grass stands were kept at a three-inch mowing height, which is a common park height. The top performer that came out of the report was tall fescue having above acceptable marks in overall quality in nearly every test trial (some below acceptable marks were due to ice damage). The results can be seen in Table 1. Kentucky bluegrass (listed as KB) was only able to produce acceptable numbers in 3 location sites even though the cultivar used (Diva) is supposed to be a highly adaptable cultivar even at low input sites. This shows the huge potential of maintaining a healthy grass stand by switching to a more low input friendly cultivar. Having to irrigate less could potentially create more money for other important procedures such as aeration. The challenge in renovating to this species is that turf studies have shown traffic tolerance is best achieved 14 weeks after establishment (Shelley and Serensits, 2012.) With the heavy traffic these fields receive, it could be difficult to have this time requirement be met. Any renovation to tall fescue on field 2 would have to address the drainage issues as well, considering tall fescue is susceptible to ice damage. This would perhaps lead to a suggestion of only renovating field 1 for the time being if water build up in the center of the field is an issue on field 2, however due to the coarse soil texture the concave nature of field 2 may not cause any problems.

Regardless of species selection, dormant seeding should be employed to ensure a head start on establishment before sports resume in the spring. Perhaps the best way to renovate this field successfully would be to shut down the field temporarily beginning in the late summer or early fall and put the workload that fields receives spread across all other fields.

To begin renovation apply a broad spectrum chemical like roundup to the existing turf to kill it off. Once this is successfully completed, scalp the field to a very low mowing height. A topdressing of soil material would then be beneficial to create a somewhat new playing surface that is less compacted to begin with. To alleviate some of the compaction below deep tine aerate the field. Once the soil temperatures are below about 40 degrees seed in the desired species and cultivar. Our recommendation would be to use a tall fescue cultivar. This species is best seeded at about 5-10 pounds of seed per 1000 square feet. Doing this dormant seed fashion would create a headstart for the seed in the spring as it could begin germinating as soon as the soil thaws. As soon as the soil begins to warm the high pH of the soil should be addressed as well. This is best done before plants are established for it to be the most effective, however it can be a bit hard to lower pH. To lower soil pH by 1 point, which would put this field at 6.6, which is nearly optimal, a recommendation of 20 pounds per 1000 square feet of elemental sulfur would suffice (Mason, 2008). This will lower the pH slowly as it requires microbes in the soil to convert sulfur to sulfuric acid. However, once complete it can work for long periods of time. Along with elemental sulfur, potash, nitrogen and phosphorus should be supplemented to the soil. Although phosphorus is ample in the soil currently, it is not mobile in the soil and requires an established root system for plants to discover it. Because the tall fescue root systems will not be established, readily available phosphorus is needed. These products should immediately be worked into the soil by starting an irrigation system which should be done for the grass seed anyway. This field would likely not be ready to play on for nearly the entire summer so it may overload other fields with play, but it would be worth it to have a healthier, thicker, and more tolerant stand in the end. Extra management strategies should be employed on those fields to keep them in better shape throughout the renovation of field 1.

Renovating field 1 will create a thicker stand of grass due to tall fescues ability to withstand droughty, non-fertile conditions like we see on this sandy site. The thicker stand and improved initial compaction level would create a much safer playing environment given the high compaction levels that we found. Aeration and topdressing should be performed at regular intervals to reduce issues of compaction in the future (aeration at every 2 to 6 weeks) this can be done with all the fields or just fields 1 and 2. Given the soils coarse texture, solid tine aeration would probably not be useful for alleviating subsurface compaction and hollow-tine aeration should be employed. Irrigation should take place immediately following aeration to alleviate stress. There are various different types of aerating that can be effective in lowering compaction levels. While the standard tine aeration is effective, and more commonly used, the effects of the standard 4 inch tines is usually short lived compared to that of deep tine aeration. Deep tine aeration will allow for a longer effect, which will help lower the compaction levels of a high traffic area, like that of a sports field (Wood, 2006). The recommendations for aeration with deep tines will lower the amount of times that aeration will be needed, as well as allow for less compacted sports fields for those that will be getting the most use. Over-seeding can also be a good way to decrease compaction as wear decreases stand of the grass. When over-seeding, aeration should also be supplemented to aid in the seeding process. Perennial ryegrass is a good grass to overseed with as it germinates quickly. By overseeding after the completion of aeration, one will have a better success rate of germination, as well as help lower the overall compaction of the turf fields. Overseeding several days before a high traffic event will allow for better seed to ground contact, and will help increase the overall germination on the field (Minnick 2014.) Dormant seeding in mid to late fall with the tall fescue cultivar that was selected for renovation would also allow for heavily worn areas to get head start in the spring again.

Mowing heights should be raised in the offseason and summer to ensure the health of the turf stand. Summer stress will damage the turf especially at low mowing heights. Mowing height should therefore be raised during the hottest months and slowly lowered over a course of weeks in transition to fall. The stress a turf receives in the summer is based on its metabolic activity at different temperatures.

The growth of cool-season grasses is slower and less efficient during hot periods the stress on a turf is already high prior to adding in low mowing height.

After a full renovation of field 1, we believe the results would justify renovating field 2 in a similar way. The other methods of action such as aerating every 2-6 weeks would be a good start for field 1 and 2 and perhaps the rest of the fields as well. These things will create a healthier microbial soil environment and more oxygen for the roots of the grass to work more efficiently, all of which lead to less compaction and an overall nicer turf.

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Group 2 Report

Matthew Bork, Jared Gamm, James Wolfin

While it may seem like the trendy and efficient thing to do, installing an artificial turf field may present more problems than benefits when being used primarily as a multi-sport field. The current fields in place at Noble Sports Park in Brooklyn Park, MN are dangerous, chemically imbalanced, and are difficult to maintain, however, it might actually be more cost effective to renovate them instead of putting in a new artificial turf field. One may believe that the large upfront cost of turf will eventually be returned over time due to the lack of maintenance required on an artificial turf field. Although artificial turf fields do not require the management techniques associated with maintaining a playable natural grass field (mowing, fertilizing, painting, etc), they come with their own set of maintenance costs that are required to keep the turf at high level of play. An artificial turf field like the one Brooklyn Park would install would support a diverse range of activities, which would further push the need for a high maintenance schedule. Artificial turf that is being used for a high level of play needs to meet an exceptional quality to be suitable for player safety and quality of play, which can only come from intense regular maintenance. In fact, Brooklyn Park notes that they want a Level A Field, which requires the highest level of maintenance, often associated with high use facilities that support a wide range of activities, primarily focused on premium level facilities for upper level competition. Most high-level athletes prefer natural turf, citing that artificial turf increases fatigue and effort. A recent study even found that athletes performing at the NCAA level in 2004-2009, were 1.39 times more likely to suffer an ACL injury on artificial turf than an natural turf (Dragoo et al. 2013). Artificial turf may seem like a logical solution to replace natural turf fields, however, we do not recommend putting in an artificial turf to replace any natural turf field that is being used for multiple sports at a high rate by competitive athletes.

After analyzing the fields in Brooklyn Park, the data indicates that the fields could be very dangerous for the players who use it. Grant Davisson, Sports Turf Manager of the Minnesota Vikings, says that when he performs a g-max test (an impact test that measures shock absorption when an object hits the ground), he would never want to see his field rise above a g-max reading of 80 gravities. He mentioned that his fields often return readings of around 60 gravities, providing a very safe surface for play. An acceptable level for play shouldn't be much higher than this if field safety is a concern. We have found, however, g-max readings of over 200 gravities in some locations of the existing Noble Sports Park fields, which poses huge risks to player safety. The Clegg device we used to measure these values could have been calibrated incorrectly, causing some errors in our data, but likely not enough to discourage us from the concern of the hard surface. The high values gathered from our g-max testing is likely from the high amount of traffic that is creating compaction throughout the field.

The soil composition in Brooklyn Park is identified as upper terrace, meaning it mainly consists of sand, gravelly sand, and loamy sand; overlain by thin deposits of silt, loam, or organic sediment (Brooklyn Park, 2003). To reduce compaction and the unsafe hardness levels, regular aeration should be practiced. If aeration is only being practiced once or twice a year, it is not enough. We would recommend aerating once or twice a month to help relieve the soil, as well as improve the health of the fields. Research performed at Auburn University found that aerating with hollow 4 inch tines every 3 weeks proved to greatly reduce restriction in compacted soils (Guertal and Han, 2013). Aerating will also promote turf health and performance when performed regularly. Aerating may seem like it is an uphill battle with maintaining turf density and quality, but aerating provides an opportune time to overseed and fertilize as well. Performing these actions will help stay ahead of any damage caused by aeration, as overseeding and fertilizing afterwards is an effective way to try and stay ahead of any damage done to the turf because the cultivation of the soil shortens the response time for fertilizers and creates a seedbed for overseeding. On a sports field like the ones at Noble Sports Park, it is probably safe to assume that safety is the main concern, so routine and proper maintenance is indicative of providing a safe field for players to use.

The weed presence throughout the two fields was surprisingly low, however, weeds can become unsightly as they spread if the problem is not addressed properly in a timely manner. We found a variety of weed species throughout the fields, mainly including broadleaf plantain, dandelion, and some white clover and creeping bentgrass. Weeds will often germinate and grow in areas that lack turf density and can also be present in areas of high potassium (dandelion), alkaline soils (plantain), areas of low fertility (plantain, white clover), or even areas that are mowed too low (creeping bentgrass, white clover). Promoting turf density is the ideal situation for suppressing weeds, but other methods such as adding organic matter or sulfur to reduce the pH, or maintaining high fertility levels with timely fertilizer applications will aid in maintaining low presence of weeds. Persistent overseeding will help improve turf density over time. We would suggest using mixtures of Kentucky bluegrass and tall fescue in overseeding applications, as these species are traffic tolerant and grow more dense than fine fescues and ryegrasses. Perennial ryegrasses will not be the most wear tolerant, but including them in the mixes is a good idea due to the rapid germination of the seed, allowing for quicker results that can help promote a suitable playing surface in a timely fashion.

The soil tests we performed on the fields present us with useful information. As mentioned above, the soil tests performed indicate the soil is natively sandy, but are good soils to work with nonetheless. We noticed very high levels of phosphorous across all the fields, and would recommend not applying any additional phosphorus to the fields until further testing reveals that levels have suppressed to a certain point. Potassium (K) levels were found to be somewhat low to medium. Nitrogen generally moves quickly through the soil, so timely applications of fertilizers containing nitrogen and potassium would be very beneficial to soil and turf health. The soil tests suggest 4 lbs of N and 3 lbs of K be applied per 1000 sq ft, or 175 lbs and 130 lbs of fertilizer per acre, respectively, throughout the course of the season. The test suggests the use of a fertilizer with the rating 20-0-15 would be ideal for the fields we tested. Applications should be performed in the late spring, late summer, and fall using ⅓ of the recommendation above for each application. The soil tests also indicated the soil pH was a little more alkaline than the optimum level. Again, organic matter can help reduce the pH, but sulfur products can also be applied to reduce the pH. Obtaining an optimum pH level will help improve overall turf health and likely demote the presence of some of the weeds present in the fields. These are all suggestions that can likely be performed with equipment that is already on hand and hopefully wouldn't raise the costs too much on the fields. The thoroughness and thoughtfulness of the maintenance is key to providing a high level product for the players to use

An important factor to keep in mind is that the Noble Sports Field complex in Brooklyn Park does not exist in a vacuum. In 2015, Brooklyn Park had 94 sports fields they were in charge of maintenance for, which rose from 78 in 2009. Greg Hoag, the Park and Building Maintenance Manager for the city of Brooklyn Park, estimated that the initial cost of implementing an artificial turf would cost around $1,000,000. Hoag also outlines the approximate budget for all athletic fields being a total of $751,495 in 2015. With such a high upfront cost, many resources would be taken away from other fields to focus on just this one field, which is only accessible by a portion of the community. As we will discuss in the next paragraph, the savings over the next years would not be enough to offset that big initial cost. In fact, the artificial turf would have to last around 100 years to make the average annual cost equal that of a natural turf field. Any high quality sports field lasting 100 years is virtually impossible, and rarely do artificial turfs even last past 15 years. One cost that often gets overlooked by sports field managers is the cost to remove and dispose of an artificial turf system. Aaron Patton states that the cost of disposing of an artificial turf could cost up to $130,000, and usually needs to be done every 8-10 years, however, properly maintained fields can last a little longer (2009).

It may seem that after installing an artificial turf system the maintenance that is needed to upkeep it is greatly decreased compared to natural turf, however, it often ends up being more expensive than natural turf due to the rigorous maintenance regimen that is necessary to keep artificial turf at an acceptable playing level. It is often cited that artificial turf comes with a big upfront cost, but saves money in the long run, but we are starting to discover that those calculations are rarely true when considering artificial turf for an area that is heavily used by multiple sports. According to Patton (2009), the average basic synthetic turf field costs $65,846 annually over a 16-year span, as compared to $33,522 in that same time period for a natural soil-based field. While this estimate may seem extreme, the costs of implementing, removal and disposal of in-fill, and re-filling can be costs that turf managers may not have considered for the long run (Grant Davisson, interview, 26 October, 2016) (Patton, 2009). While artificial turf has the benefit of not needing to be mowed, it requires additional maintenance in other areas that far exceed the need to mow. Maintenance regimes like cleaning, repairing, in-filling rubber, disinfecting, and protecting the turf are practices that need to be handled on a regular basis. Additional, painting and erasing of temporary lines on the turf contribute to resources spent, all of which are done to ensure the playing surface is up to playing standards (Patton, 2009).Table 1 below lays out the annual costs for maintenance of each type of field, and includes the average annual cost after considering implementation cost. This table is a representation of the numbers we received from Greg Hoag, and shows that maintenance costs for artificial and natural turf are fairly close to each other, however, when we consider the large up front cost of an artificial turf, it shows that artificial turf has a much higher average cost over a 10 year period. This table also leaves out some key expenses of artificial turf. For the maintenance regimens that are listed, at least two new pieces of maintenance equipment would be needed, including a machine for cleaning the turf, which could run as high as $63,000 (Grant Davisson, interview, 26 October, 2016), and a machine for adding infill which could cost tens of thousands of dollars. For a field that would be used for public sports and recreation, irrigation may also be a concern that could potentially increase the water and ecological cost. Studies have shown that an air temperatures of 94 degrees fahrenheit can equate to artificial turf surface temperatures of over 150 degrees fahrenheit (Patton, 2009). Because of these increased temperatures, it can be necessary to use irrigation to cool surface temperatures to a suitable playing temperature. With the need for irrigation on artificial turf surfaces, an additional cost of implementing a system to deal with water is needed, further increasing the total cost of implementing an artificial turf. If these maintenance demands aren't met, often the turf will degrade, requiring renovation more frequently. However, potentially one of the biggest concern associated with limited maintenance, is player safety and performance.

In addition to the financial burden associated with installing and maintaining an artificial turf field, further issues arise when comparing the in-game performance of artificial turf fields to grass fields. Although the current fields in place at Noble Sports Park are currently dangerous, there are a number of physiological and player safety concerns associated with artificial turf fields. A study of young soccer players compared heart rate and blood lactate production on artificial turf, natural grass, and a treadmill. When running the same drills on each surface, it was found that athletes observed a higher blood lactose concentration and heart rate when running on artificial turf fields as compared to grass fields. Additionally, when controlling for blood lactate levels across each surface, players observed higher heart rates and lower running speeds on artificial turf relative to natural grass. Differences in speed and heart rate exceeded 1KM/H and 4 beats/minute, respectively, under these conditions (Di Michele et al. 2009). These results indicate that an athlete will feel as though they are exerting a higher physical effort when performing equal tasks while playing on an artificial turf field as opposed to a natural grass field. Additional studies have found that there are injury risks associated with playing on a turf field instead of a natural grass field. Research suggests that athletes playing on artificial turf fields are more prone to ankle injuries, and that female soccer players may be more susceptible to severe injuries. A study following 157 different teams in a Norwegian soccer league found that athletes on artificial turf were 40% more likely to suffer an ankle sprain, and were twice as susceptible to severe injuries (Steffen et al. 2007; Williams et al. 2012). Based on the results of these experiments, it appears that the athletes playing at Noble Sports Park would be subject to higher levels of physiological stress and higher rates of injury if a transition from natural grass to artificial turf was implemented. Further health complications arise when considering how environmental conditions are perceived on artificial turf. As previously stated, an air temperature of 94℉ can result in a synthetic turf temperature of 165℉. Comparatively, at the same air temperature, a bermudagrass natural turf field observes a surface temperature of 104℉ (Patton, 2009). This 61 degree difference in perceived temperature indicates that synthetic turf fields may create unsafe playing conditions on warm days, as athletes will be more prone to the dangers associated with excessive heat (heat stroke, dehydration, heat cramps, fatigue, etc).

The performance issues associated with an artificial turf field are not restricted to player safety issues, as there is evidence to suggest that quality of play suffers when athletes perform on an artificial turf field instead of a grass field. An analysis of playing surfaces conducted by the London Sports Council found that ball bounce and ball roll are negatively affected when performing on an artificial turf field rather than a natural grass field, and that players found basic athletic feats such as starting, stopping, and turning more difficult (Winterbottom 1985). A similar study comparing more modern playing surfaces reported that soccer players felt as though they exhibited poorer ball control when performing on an artificial turf field rather than a natural grass field. Furthermore, it was found that playing surface may have an affect on an athlete's style of play, as soccer players were less willing to perform a slide tackle on artificial turf. This suggests that a player's mentality and aggression may be compromised when performing on an artificial turf field rather than a natural grass field. A questionnaire issued during this study also noted that male players displayed an overall preference for natural grass fields (Andersson et al. 2007).

After a thorough evaluation of the fields present at Noble Sports Park and carefully considering the alternate option of installing an artificial turf field, we have concluded that it would be beneficial to keep all fields at Noble Sports Park as grass fields. Although there are currently imperfections at these fields including hardness, weed pressure, and chemical build up, these flaws can be corrected by implementing responsible turf management practices. Additionally, the high cost of installation and maintenance associated with an artificial turf field make this option less appealing. It should also be noted that extensive research has been conducted comparing artificial turf fields to natural grass fields, and the results of these projects indicate that natural grass fields outperform artificial turf fields in terms of player safety, quality of play, and player approval. When considering these factors it is evident that the difficulties associated with artificial turf fields do not warrant a transition away from natural grass playing fields.

Tables and Figures

Table 1: Yearly Cost of a Natural and Artificial Turf Field

Practice	**Annual Maintenance Cost of Natural Turf**	**Annual Maintenance Cost of Artificial Turf**
Seam repairs		$8000
Crumb rubber top dress		$5000
Clean/Disinfect		$500
Sweep/level infill		$7200
Paint field		$500
Mowing	$2500	
Growth Regulator for lines	$250	
Top dressing	$2600	
Irrigation	$5500	
Fertilizer	$2000	
Painting lines (weekly x26)	$1500	
Initial field layout	$1000	
Aeration	$300	
Weed control	$2500	
Overseeding	$1500	
Miscellaneous	$1000	$1000
Total Estimated Annual Maintenance Cost	**$20,650**	**$22,200**
Initial Implementation Cost	**$110,000**	**$1,000,000**
Total Cost	**$316,500**	**$1,222,000**
Average Yearly Cost over 10 Years	**$31,650**	**$122,200**

Noble Sports Park, Brooklyn Park, MN

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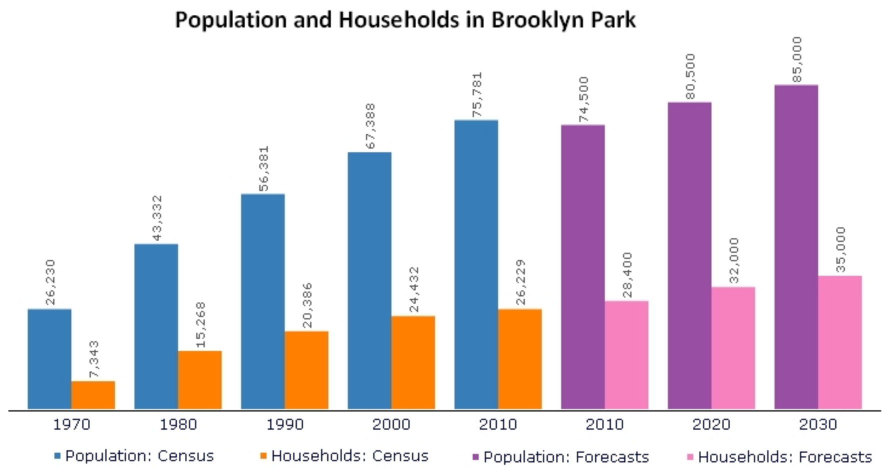
Group 3 Report

David Deiman, Takara Thomas, Ashley Kellen

Brooklyn Park is one of the largest suburban cities within the metro area, and a population of 78,728 makes it the fourth largest city here in the Twin Cities. It is a diverse, connected, and growing community, with 50% of its population being people of color (Hoag, 2016).



(Population and Households in Brooklyn Park, www.brooklynpark.org)

In a poll given by the Morris Leatherman Company (2015), 91% of those surveyed stated " yes" as to whether or not they felt the current mix of recreational opportunities met the needs of their family members. There is a strong sense of value and satisfaction for current parks and recreation, and it would be best to make sure that the community members continue to have spaces where they can relax and enjoy themselves.

Upon visiting Brooklyn Park and assessing sports fields numbers one and two, we found many issues with the quality of the turfgrass present at Noble Sports Park. Damage due to excessive play from soccer and football players has left thin turf and compact soil, especially down the center of the fields. Water drainage didn't seem to be an issue because of the graded fields, but only a couple of drains are placed around the perimeter. Below the surface, the fields have irrigation that is sourced from a well, and is used daily or whenever needed. A crew is sent throughout the grounds to repair the systems during the summer months, and blow them out in the fall.

Our soil tests of each field showed that they both have high concentrations of phosphorus (40 ppm of Olsen phosphorus, 93 ppm of Bray 1 phosphorus), medium-low amounts of potassium (61-76 ppm), and a pH around 7.6-7.7 (Table 1)

Table 1: Soil Test Results for Fields One and Two

Sample/Field Number: NPS1 — SOIL TEST RESULTS

Estimated Soil Texture	Organic Matter %	Soluble Salts mmhos/cm	pH	Buffer Index	Nitrate NO3-N ppm	Olsen Phosphorus ppm P	Bray 1 Phosphorus ppm P	Potassium ppm K	Sulfur SO4 -S ppm	Zinc ppm	Iron ppm	Manganese ppm	Copper ppm	Boron ppm	Calcium ppm	Magnesium ppm	Lead ppm
Coarse	**2.1**		**7.6**			**40**	**93**	**61**							**1236**	**232**	

Field 1 Soil Test Results

Sample/Field Number: NPS2 — SOIL TEST RESULTS

Estimated Soil Texture	Organic Matter %	Soluble Salts mmhos/cm	pH	Buffer Index	Nitrate NO3-N ppm	Olsen Phosphorus ppm P	Bray 1 Phosphorus ppm P	Potassium ppm K	Sulfur SO4 -S ppm	Zinc ppm	Iron ppm	Manganese ppm	Copper ppm	Boron ppm	Calcium ppm	Magnesium ppm	Lead ppm
Coarse	**3.2**		**7.7**			**31**	**63**	**76**							**1575**	**287**	

Field 2 Soil Test Results

We took surface hardness tests throughout field one and two (Table 2) with a Clegg, a device used to read surface hardness, and found that the fields could have compaction issues. In the NFL, the preferred hardness of the field needs to be below 100 GMAX in order to keep the players safe (GMAX is a unit of measurement for surface hardness). Nowhere on the two fields did the readings average below 110 GMAX. This is very dangerous for those utilizing the turf, as the hardness of the fields can amplify the effects of a fall. The NFL has set these recommendations for a reason, and so it would be best to abide by those in order to keep the user safe. Unfortunately, the equipment we used hasn't recently been calibrated, but even walking on the field to take measurements proved the ground to be quite hard.

Table 2: Clegg readings from Noble Sports Park

Clegg Readings (in Gmax)							
Field 1				Field 2			
	Left Side	Center	Right Side		Left Side	Center	Right Side
North Side	129	209	148	North Side	101	281	116
	122	185	177		148	198	133
	111	148	201		163	261	155
South Side	96	216	205	South Side	122	222	163
	96	177	135		135	185	166
	111	172	113		109	163	100
Average Reading	111	185	163	Average Reading	130	218	139

These issues related to soil hardness could be solved with a few general turfgrass maintenance practices, but it seems that there have been some issues regarding the completion of all of those tasks. When interviewed, Greg Hoag had mentioned that the fields had only been aerated once the previous summer. For a sports field as busy as Noble Park, aeration should be done more frequently, about 2-3 times a year (Atkinson et. al, 2012). In addition to that, the fields are also topdressed high use areas when needed, using a mix of 80% sand and 20% peat formula. One of the best thing that could be done to these fields is to aerate more often during the summer.

While further questioning Greg, it was discovered that the fields are treated once a year with fertilizer, around June 10th. Through our observations of the fields, we identified some instances of broadleaf plantains and annual bluegrass present throughout the turf. It was mentioned that a broadleaf plantain pesticide (Speedzone) is used in order to keep the weeds under control. We identified that the majority of the grass on the field is Kentucky bluegrass, but there were some patches of perennial ryegrass as well.

Some challenges associated with the fields are that some of the maintenance practices (like aerating) aren't being completed often enough during the season due to limited staffing. The turf cannot get the care it needs because of a deficiency in the number of crew members on the team. Another challenge is that it can often be hard to regulate who uses the fields. Since they are public fields, anyone can use them throughout the day, other than at night when fields are reserved for sports events. Sports Noble Park is directly adjacent to Woodland Elementary School, Brooklyn Park-Park and Ride, and multiple churches. This makes it a central location for a lot of activity and traffic, increasing the potential for unscheduled visitors. The last challenge is that since these fields are so popular, closing them down for maintenance or recovery from excessive use is hard to do. For instance, if one field is closed, the other gets twice as much traffic, causing the turf to get extra abuse from the players.

One of the proposed solutions to these issues is to replace some fields with artificial turf at Noble Sports Park. Though there are many benefits that come with installing these types of synthetic materials (such as: fewer man hours spent on mowing, fewer resources used on watering and fertilizing, increased durability, and the absence of diseases and pests), we have found that these benefits are significantly outweighed by the costs. One of the main reasons someone may think about installing an artificial turf is to reduce the amount of maintenance time and costs needed. There is a belief that because the grass is not growing, it needs very little to no care. However in actuality, there is a lot of care that goes into maintaining the artificial grasses.

An important aspect of artificial turfgrass care is in making sure the rubber base layer of the turf remains free of debris. Especially in the case of an outdoor field, the turf is exposed to anything that happens to pass, and so it must be cleaned on a regular basis. The machines used to do this can be quite costly, and may even need to be imported from outside of the country. It is also important to maintain the crumb rubber on the surface of the field, as it absorbs the shock from the players. Crumb rubber is a material made of ground up tires that are a little bigger than sand particles. Their size makes them very susceptible to displacement from players, wind, and rain, making crumb rubber susceptible to some maintenance and safety concerns. For instance, during large storm events in the summer, the crumb rubber can be completely washed or blown away to the edges of the field. Consequently, the field would need to be closed down in cases like this in order to replace all of the crumb rubber (which is not cheap), taking away from man hours that could be used for other important tasks.

When it isn't storming in the summer, and instead it's sunny and hot, concerns with field temperatures arise. Crumb rubber is black, which has the tendency to attract heat. The field surface and immediate surroundings become noticeably warmer and can become dangerous to the players and other users of the turf. In the case of Noble Sports Park, the fields are all outside, where there is a constant exposure to the sun. Potential health risks like heat stroke, increased instances of dehydration, and nausea can occur more often due to the increases in surface temperature (Williams and Pulley, 2002).

Additionally, the actual playing experience may be affected by the physical differences of an artificial turf. The texture and resistance of an artificial turf is similar to that of a traditional field, but not quite the same. The movement of an individual or an object across the field may be more difficult, as the surface may not be as smooth. The combination of both heat exposure and field surface differences can lead to discomfort among people utilizing the fields. It is important that the turf is suitable everyone, regardless of age. It is crucial that the turf does not pose any particular health risks to any of the users, particularly children and the elderly.

Finally, the cost comparison between natural and synthetic turfs show that it costs less per year to maintain natural turf than artificial turf (Table 3a) (Sports Turf Managers Association, p. 7-11). In addition to the high initial payment for installing the artificial turf, there is also the expense of getting special equipment for the maintenance of the artificial field (Table

3b). The costs for synthetic turf maintenance can add up to over $104,000 compared to the $20,000 to maintain natural turf.

Table 3a: Comparison of Cost Between Natural and Synthetic Turf Maintenance

2004-2005 Maintenance Budget for Synthetic Infill Field with a three year old surface

Seam Repairs (outside contractor; $30 per linear foot)	$8,000
Apply Crumb Rubber (1 time per year; 20 hours per application; 10 tons of topdressing at $500 per ton)	$5,000
Spray Field (4 times per year; 3.5 oz rate per 1000 square feet; 3 hours each; 12 hours per year)	$216
Fabric softener at $7 per 64 oz container	$120
Disinfectant at $5 per gallon	$100
Sweep Field (Parker Sweeper; 4 times per year; 8 hours each; 32 hours per year)	$1,500
Broom	$500
Groomer	$2,800
Hand Pick (3 times per week; 1 hour each; 156 hours per year at $18 per hour)	$2,800
Paint Field (2 times per year; 30 hours each; 60 hours per year; 30-40 gallons per year at $25 per gallon)	$1,000
Total Straight Hourly Cost (Field only; 280 hours at $18 per hour; benefits not included)	$5,040
Total Supply Cost	$6,220
Total Equipment Cost	$3,500
Total Outside Contractor Repairs	$8,000
Total Maintenance Cost 2004-2005	**$22,760**

Bottom Line: Michigan State University synthetic field costs $22,760 per year to maintain.

2009 Sand Based Soccer Field Maintenance Cost Estimates

Total Area: 114,000 square feet

Description of Activity	Man Hours	Man Hour Cost	Product	Product Cost	Total Activity Cost
50 Mowings / Season	113	2,228.36			$2,228.36
Growth Regulator, Once Per Month	12	236.64	Primo	1,227.60	$1,464.24
Topdressing, 5 Applications Per Year	31.5	621.18	Sand	1,987.50	$2,608.68
Water, 1 Acre Inch Per Week / 26 Weeks	6	118.32	City Water	5,440.50	$5,558.82
Fertilizer @ 6.1 #s N / Year	12	236.64	Fertilizers	1,548.00	$1,784.64
Paint, 6 Applications Per Season / 20-5 Gallon Pails	45	887.40	Paint	378.75	$1,266.15
Aeration, 3 Times Per Year	13.5	266.22	Verti-Drain		$266.22
Fungicide, Four Applications / Season	8	157.76	Disarm 480 SC	1,575.00	$1,732.76
Over-Seeding, Once Per Season	5	98.60	Seed	997.50	$1,096.10
Herbicide, One Application Per Season	2	39.44	Herbicide	22.66	$62.10
Fence-line Maintenance, 2 Apps. Per Year	8	157.76	Control Products	125.00	$282.76
Miscellaneous	50	986.00	Misc. Products	200.00	$1,186.00
Pre-emergent Applications	4	78.88	Drive 75 DF	360.18	$439.06
Insecticide Applications			Dylox		
Sports Lighting, 10 events @ 3 hrs in length per season			Electricity	402.60	$402.60
Totals		**$6,113.20**		**$14,265.29**	**$20,378.49**

Labor Cost: $16.44 x 20% benefits = $19.72 per hour

Bottom Line: North Scott Community School District's sand based soccer field costs $20,378.49 per year to maintain.

Table 3b: synthetic turf maintenance equipment costs

Synthetic – Michigan State University

Outside Contractor Maintenance Charges

Consultation and/or training	$1,200-$3,000 per day plus expenses
Repairs	$30-$70 per linear foot
Crumb Rubber	$.50-$1.00 per pound applied

Synthetic Turf Maintenance Equipment

Boom Sprayer	$1,000-$35,000
Sweeper	$1,500-$20,000
Broom	$500-$3,000
Painter	$500-$3,000
Groomer	$1,500-$2,000
Cart (to tow equipment)	$2,500-$16,000
Field Magnet	$500-$1,000
Rollers	$250-$2,000
Total	**$8,250-82,000**

In order to improve the quality of the fields at Noble Sports Park, it is our recommendation that the fields be interseeded with a turf-type, semi-dwarf tall fescue cultivar.

Tall fescue is known for its tolerance of heat, wear, and drought (Christians, 2011, p. 40). Turf-type tall fescue cultivars have a rhizomatous growth habit that will allow for quicker establishment, faster recovery, and denser turf coverage. According to Eric Watkins and William Meyer, dwarf-type tall fescue cultivars have narrower leaves and a higher turf density than the other turf-type tall fescue categories (Meyer & Watkins, 2005, p.618). Table 4, taken from the study, shows that the quality rating was highest for the semi-dwarf cultivars and the susceptibility to brown patch was fairly low.

Table 4: Performance of tall fescue types in a turf trial seeded in Sept. 1998

	Turf quality[z]	Brown patch[y]			Tiller no.[v]
Type	1999	2000	1999[x]	2000[w]	1999
Semi-dwarf	5.7	6.1	3.5	5.3	108.5
Early semi-dwarf	5.7	6.0	4.0	5.0	106.6
Dwarf	5.2	6.0	2.3	4.5	110.8
Standard	4.9	4.4	4.0	5.0	101.0
Forage/early standard	2.2	1.3	6.0	4.7	74.1
Minimum significant difference$_{0.05}$[u]	0.6	0.9	1.4	1.6	15.8

[z]1 to 9 scale, 9 = best turf quality. The 1999 and 2000 data are averages of 13 and 9 rating dates, respectively.
[y]1 to 9 scale, 9 = least brown patch disease.
[x]Rating taken 9 Aug. 1999.
[w]Average of two rating dates taken 8 and 15 Aug.
[v]Tiller number determined by averaging number of tillers in two samples (91.5 cm^2 each) per plot taken 9 Sept. 1999.
[u]Tukey's minimum significant difference.

We would also recommend an increase in the amount of staff members. Field maintenance practices like aeration and topdressing should be done more often throughout the year, rather than annually. Doing so will create healthier, safer playing fields. Interseeding with turf-type tall fescue blends and increasing the number of times the fields are aerated during the year will significantly improve the density of the turf and reduce compaction to more acceptable and safer standards.

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Group 4 Report

Michael Laskowski, Jack Tschida and Tyler Quam

Introduction

The Noble Sports Park (NSP) is a vital asset to the Brooklyn Park community and it is the duty of the parks and recreation department to effectively maintain the space. This has been a challenge as the growing population increases demand of the park for all sorts of uses throughout the spring, summer and fall. According to the 2012 Brooklyn Park Recreation and Park Master Plan, the city projects a 13-17% population growth of residents ages 5-24 from 2010-2030. Current field reservation trends show the 5-24 age bracket are the primary users of the NSP soccer fields. Currently, NSP has six soccer fields that will be the focus of this analysis and recommendation for the Brooklyn Park recreation department to use at their will. Brooklyn Park wants to provide the community with the best playing conditions while considering safety and the needs of all stakeholders. The following analysis will consider the needs of Brooklyn Park's residents and focus on the current conditions of the soccer fields, recommendations to increase the quality of the natural turf and opportunities for replacement with artificial turf.

Current Status of NSP Soccer Fields

Noble Sports Park has six A-level soccer fields which are defined as, "Highest level of maintenance - associated with highly visible or high use facilities which are heavily scheduled for programmed activities for all age levels, particular focus on premium facilities for upper level programs. Examples of areas include: Sport fields within our athletic sport complexes," by the City of Brooklyn Park. Current management practices of all the fields are dictated by Park Facilities Operations, Maintenance & Improvements Policy 5.30. Over the past six years fields 1 and 2 have seen a large increase in reservations, on average increasing by 14 reservations per year, shown in Figure 1, below.

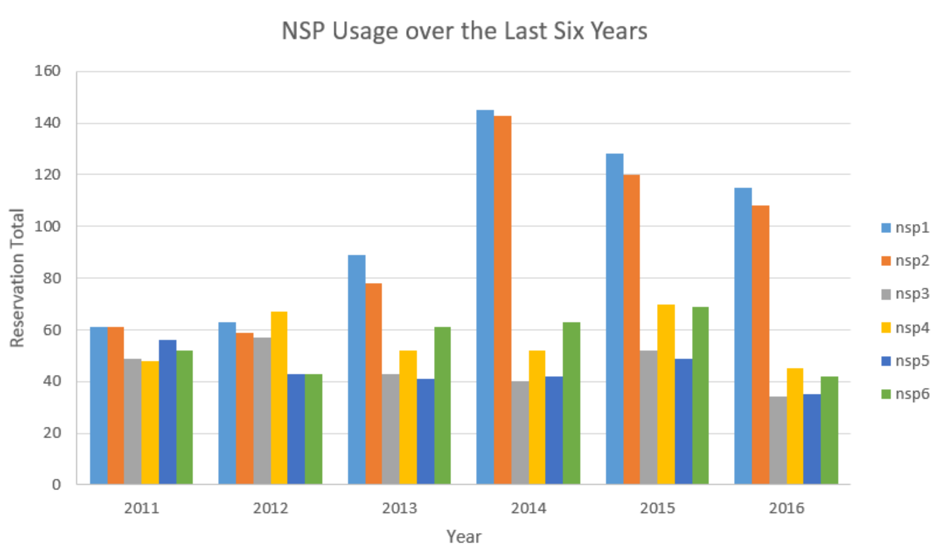

Figure 1.

This increased demand is partly due to increasing population and a policy change allowing football to be played fields 1 and 2. The result is more wear and tear on the turf causing compaction, lower turf density, less drainage, and other problems associated with stress. Figure 2, below, shows the BPAA football and BPAA soccer are the most frequent users of the fields.

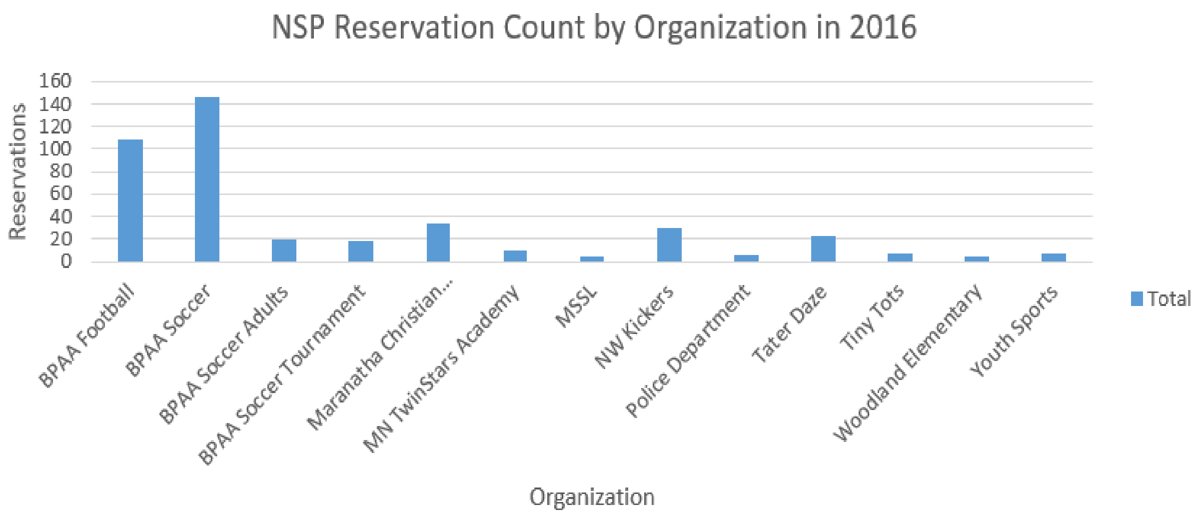

Figure 2.

Both sports utilize the center of the field heavily over the course of a game or practice, resulting in greater compaction and wear in those areas especially center field and near goalie boxes. Football coaches also tend to use the one corner of a field for intense, repetitive drills during practice which creates a distinct wear pattern in that area. Educating and encouraging coaches to rotate corners or use other areas of the turf off the playing field should be considered to alleviate that wear.

Technical Assessment of the Fields

Plant Species Present

A survey of the six soccer fields revealed there are two major grass species present: Kentucky bluegrass (*Poa pratensis)* and perennial ryegrass, (*Lolium perenne*). Fields 1 and 2 had a distinct strip of perennial ryegrass down the center third of the field from overseeding a couple weeks prior to the survey. Fields 3-6 did not have this same overseeding effect. All fields were almost weed free, except the occasional dandelion or broadleaf plantain. Fields 3 and 4 had distinct patches of tall fescue, *Festuca arundinacea*, near the corners. Specific turf cultivars are unknown.

Soil Tests

Soil samples were collected from each field and analyzed at the University of Minnesota Soil Testing Lab. The results are summarized in Table 1 below. The most significant result of this test was the high levels of phosphorus. To reduce the amount of phosphorous we recommend not applying any phosphorous to the turf.

	Present								Annual Recommendation			
Field	Texture	Organic Matter %	pH	Olsen P Test ppm	Bray P Test ppm	K ppm	Ca ppm	Mg ppm	N lbs/ 1000 ft^2	P lbs/ 1000 ft^2	K lbs/ 1000 ft^2	Ratio N-P-K
NSP1	coarse	2.1	7.6	40	93	61	1236	232	4	0	3	20-0-15
NSP2	coarse	3.2	7.7	31	63	76	1575	287	3	0	3	10-0-10
NSP3	coarse	1.8	7.8	50	100	67	1113	238	4	0	3	20-0-15
NSP4	coarse	1.4	7.7	50	100	69	951	187	4	0	3	20-0-15
NSP5	coarse	1.4	7.9	42	100	49	1199	243	4	0	4	10-0-10
NSP6	coarse	1.4	7.8	50	94	60	1006	216	4	0	3	20-0-15

Table 1: Soil test results. The organic matter was below the recommended 5%.The pH is slightly high for turfgrass, ideally between 6.0-7.0, and the phosphorus levels were very high.

Surface Hardness

Surface hardness was testing using a Clegg impact tester; results were troubling and far above the recommendations of many safety organizations from around the country (it should be noted that the Clegg we used had not been properly calibrated recently, but even so, the results were quite high). Most of the test results were well above the 100 gravities threshold used by the National Football League (NFL). These results are from high compaction, inadequate aeration and exposed soil from heavy traffic. The highest readings were found at center field and near the goalie box as expected. These high levels are certainly concerns for players safety and should be a high concern for staff and organizations.

Irrigation and Drainage

The NSP complex is located on the well-drained Anoka sand plain. All six fields are irrigated as needed from April until late October. The fields are gently sloped away from one another to prevent water from pooling on the fields. Drainage may be reduced on fields 1 and 2 due to a layered soil structure from the import of silty loam soil on top of Anoka sand soil. The top level of soil drainage can be improved through hollow tine aeration followed by topdressing with sand.

Fertility Application

Park Facilities Operations, Maintenance & Improvements Policy 5.30 specifies the use of fertilizer twice per year. We recommend fertilizing with a slow release formulation in late May to avoid leaf spot disease resulting from cool wet weather (Harper, 2016). Due to the sandy soils in the area we also recommend fertilizing a second time in early September with a final application in early November (Powell, n.d.) to promote deeper root growth in the plants.

Pesticide Application

Policy 5.30 also states broadleaf herbicides are applied at least twice per year and selectively as needed. Very few weeds were present on the fields themselves indicating a good herbicide program.

Cultivation

Fields are mowed twice per week from April to October and as needed in March and November. Fields are aerated maybe once per year in September using 6 in or 12 in, hollow or solid tines. Current aeration practices are limited by time and resources dedicated to higher priority tasks.

Microclimates

No significant depressions or low spots were observed in the fields. Fields 1 and 2 have artificial lighting, but did not have an obvious effect on turf quality or management

Other Practices

Fields are painted once per week from April to November. Paint is pre-mixed with a plant growth regulator (PGR) designed to reduce the growth rate and extend the life of the paint. If the paint does not contain a PGR, the grass is mowed immediately before painting. Overseeding is done on an as needed basis. There are three seed mixtures in stock depending on the need and timing of each field, they are: 80:20 KBG:PR, 50:50 KBG:PR and 0:1 KBG:PR. Overseeding is typically done in the center third of the field where the turf receives the most wear. Higher ratios of perennial ryegrass are used when grass needs to emerge quickly, such as just before a game or towards the end of the growing season.

Recommendations

Natural Turf

While the early summer provides quality turf for users, the heavy use chews up the turf quickly by the end of the fall. When our team observed the turf, managers had overseeded with perennial ryegrass, but there was a clear lack of turf in many spots on the playing surface like midfield and directly in front of the goal. The turf stands can be improved by starting a few common and easy cultivation methods. Due to high compaction, it is recommended to start an annual aerating program. Aeration should be done in the spring on the center of all of the fields before the athletic season begins. It can also be done in the fall after the season is over but before the ground freezes.This will be especially important for the middle third of fields 1 and 2 as those see the highest traffic.

Both the 1:0 Kentucky bluegrass and 1:0 perennial ryegrass have a designated purpose in the program and should be continued. However, we recommend increasing the ratio of Kentucky bluegrass to perennial ryegrass to 80-90% KBG to 10-20% PR (Landschoot, 2016). As far as cultivar selection, we recommend a blend of 4-5 Kentucky bluegrass cultivars that do well in athletic field environments and 2-3 cultivars of perennial ryegrass. KBG cultivars include Blue Note, Endurance, PST-K9-90, Prosperity, and Greenstar (Grimshaw, 2015, NTEP, 2015). Perennial ryegrass cultivars include PL5 Comp, Evolution, 2BDT, RAD-PR79, and APR9709 (Qu et al, 2015). Additional cultivars can be found by looking at NTEP .

We also believe that replacing your fertilizer would be beneficial to the management of the fields at Noble Sports Park. Switching to a fertilizer that has no phosphorus in it will decrease the amount of phosphorous in the soil. From the soil sample we took in from the field, we found that there was a higher amount of phosphorus than what it recommended. An increase in the amount of phosphorous paired with the high compaction currently present in the fields has a higher chance for runoff. Phosphorus runoff when present in water creates algae blooms, depleting the water of oxygen that is necessary for aquatic animals.

One option that the city of Brooklyn Park can do to improve their athletic fields is topdressing with sand throughout the summer. The construction of a sand based field is costly and time consuming but topdressing with sand can over time provide the same benefits. Sand has a higher porosity than silt or clay which leads to better water infiltration and reduced compaction of the soil. Research has shown that wear resistance is greatest when the turfgrass has received 0.5-inch topdressing depth. As topdressing depths increased, the turfgrass density increased. Although as the topdressing depths increased, wear resistance decreased slightly. Scientists concluded that over a two year period a 1.0 inch (0.5 inches per summer) provided the greatest wear resistance with increased turfgrass density. They topdressed with sand anywhere between two to eight applications over the summer based on their desired topdressing depth. The accumulation of sand overtime has a dilution effect in the soil. It will reduce organic matter content as well as reduce compaction and increase water infiltration. Both of these characteristics are great for athletic fields and will make it much easier to manage. This strategy is cost effective as sand is relatively cheap as well as it keeps the field in play from May until October. Over time this strategy will hopefully increase turfgrass density and improve the wear resistance of the turfgrass (Kowalewski et al, 2010).

	Natural Turf	Artificial Turf
Base Preparation	$150,000	$320,000
Materials	$220,000	$380,000
Maintenance	$200,000	$50,000
Total	$570,000	$750,000

Table 2: This table shows the difference in cost between natural turf and artificial turf based on the numbers from the company FieldTurf. The base preparation includes excavation, engineering, and construction of the field. The materials include sodding for the natural turf and the company's product FieldTurf for the synthetic field. The maintenance is the estimated cost of mowing, spraying, herbicides, and other general maintenance associated with both fields. These values are approximations and are subjected to change each year depending on where the field is located. This data is based on a 10 year period on an average sized athletic field of 80,000 square feet (FieldTurf vs. Natural Grass).

Synthetic Turf Installation

Although synthetic turf is a viable option we felt that continuing to manage the natural turf was the best way to go. There is a large amount of time and money that are invested into synthetic fields and without the proper management, the benefits of having synthetic turf are quickly diminished. The total installation of a synthetic turf field can take anywhere between 1 to 2 months. As the installation cannot be done in the winter, the field will need to be taken out of use for a considerable amount of time. Building the base of for the field cost around $320,000, which includes the excavation of the site and the installation of both a drainage system as well as geotextile fabric. The installation of the field requires placing the turf, sewing in the turf, and installing the infill of sand or crumb rubber which adds another $380,000 onto the installation cost. The entire installation of a synthetic field is roughly $750,000. These costs occur every 8-10 years as the field will need to be replaced due to wear of the fabric and fibers depending on use and common maintenance practices (FieldTurf vs. Natural Grass).

An important consideration for installing a synthetic field turf is the general maintenance associated with the field. Brooklyn Park would need to purchase new equipment including sweepers ($1,000-$35,000), mechanical broom ($500-$3,000), groomer ($1,500-$2,000), field magnet ($500-$1,000), rollers ($250-$2,000), topdresser ($4,500-$10,000), and aerators ($3,500-$17,000) to properly keep up (Toxic Use Reduction Institute, 2016). Surface brushing is recommended every two weeks and after heavy rains to clean any debris. Raking is necessary every 4-6 weeks in order to redistribute the crumb rubber around the field and keep fill levels consistent. Aerating is also required 2-3 times a year to reduce compaction as well as possibly adding new infill as it settles. Chemicals such as anti-static treatments and scrub detergents are needed to limit static and clean the field. With all of the new equipment and materials needed for a synthetic field, the city of Brooklyn Park may have to build another shed for storage if it cannot fit all of the new equipment. However, as there are an increased number of artificial turfs in the Twin Cities, there could be an opportunity to share this equipment with neighboring communities or contracting out the work to a private company. This would greatly reduce the annual cost of the turf. Despite these aspects, the day-to-day cost of turf maintenance would decrease, but it is not a guarantee that it will be enough to cover the up-front cost (FieldTurf Maintenance Guidelines).

Wearability is also a huge concern for this big investment. Many teams and organizations like the idea of playing on turf. The city would likely be able to book more events on the fields each day and forsure a longer playing season, but this also decreases the lifespan on the turf. Excessive heat is a concern for synthetic fields due to the black infill absorbing the heat. The field may become unsafe for the athletes if the temperature is exceedingly hot summer temperatures (McNitt, 2005).

We feel as though synthetic turf is currently not the best option for this site due to the lack of resources available for the installation and maintenance of synthetic fields. We feel that NSP should stay as natural turf, but a possible project for synthetic turf would likely be beneficial to the community.

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