Town of Maplewood, NJ
DeHart Field

Project Evaluation and Technical Review
Natural Turf Management Recommendations

Prepared by:
Chip Osborne
Osborne Organics
December 2011

Background

Report Organization

This report is divided into a number of sections. The scope of the report will be two-fold. It will address the current field conditions as they appeared in early November that seem to be in part the result of construction issues. All documents including the Project Manual and contract will be evaluated to try to determine the underlying issues. Post construction turf management practices will be analyzed. An opinion will be rendered on the combination of factors that led us to where we are at this point.

The report will then address the protocols of natural turf management that include a framework for evaluating and managing soil chemistry and microbial activity, elements of and transition to natural-based practices, site analysis, and recommendations. More specifically, soil test results that include nutrient, textural, and biological analyses are included. In so doing, the report documents the existing physical condition of the turf areas and establishes a baseline soil analysis for chemistry, texture, biology, and nutrient availability. The current soil analysis will be compared to the soil analysis done in 2009.

Staff provided information on current and past management programs and practices, as well the history of the sites. Goals for the turf areas were discussed and will be incorporated in the recommendations in the report. A complete annual program will be offered designed to address and meet site objectives and expectations.

Existing Field Condition

There are serious problems with the field as any casual observer can see. A thorough analysis will be performed outlining the current physical condition of the field. The photographs that follow depict the strengths and weaknesses of the field and the analysis outlined above will identify some of the reasons for the condition we have at this time.

Turf Management Orientation

It is important as this exploration of alternative turf management practices moves forward that clear expectations for aesthetic standards be defined. There are different levels of management with very different associated costs. Turf management levels determine the cultural intensity required in a maintenance program to meet expectations for a specific turf area. Cultural intensity reflects the amount of labor and material inputs required to meet expectations. Higher levels of cultural intensity meet higher expectations and reflect a higher cost.

In attempting to meet these standards, this report contrasts conventional chemical-intensive practices with natural turf management methods that eliminate hazardous materials. Conventional turf management programs are generally centered on a synthetic product approach that continually treats symptoms. Pesticides by definition kill, repel, or mitigate a pest. They do not grow grass.

Our approach will be to implement a strategy that proactively solves problems by creating a healthy soil and turf grass system. We are following a Systems Approach to Natural Turf Management® that is designed to put a series of preventative steps in place that will solve problems. This approach forms the basis for our recommendations. The natural approach adopts a systems approach that is designed to put a series of preventive steps in place to prevent and solve problems. The systems approach is based

on three concepts, including (i) natural, organic product where use is governed by soil testing or site considerations, (ii) the acknowledgement that the soil biomass plays a critical role in fertility, and (iii) specific and sound cultural practices. It is a "feed-the-soil" approach that centers on natural, organic fertilization, microbial inoculants, compost teas, microbial food sources, and topdressing as needed with high quality finished compost. It is a program that supports the natural processes that nature has already in put in motion. These inputs, along with very specific cultural practices that include mowing, aeration, irrigation, and over-seeding form the basis of the program.

Cultural intensity and the level of management correlates directly with budgeted dollars committed to a project. In some respects, programs can be tailored to make the best use of available resources, financial and otherwise. One fact is a given in either a conventional or natural turf management program; minimal product and labor inputs meet low expectations, while higher levels of inputs meet higher expectations. The analysis in the report is intended to assist in the design of a program that effectively manages the turf relative to the level of expectation. However, it is clear that with the expanse of grounds to be maintained, levels of management will be created to meet site-specific expectations and focus on available budget resources.

Transitioning

When a natural management program is being put in place, the transition period requires specific planning and practices. It is during this timeframe when new products are put in place and specific cultural practices adopted. The most important element of the transition is the attention to soil, not just texture and chemistry, but the biomass as well. Success is achieved by focusing on the living portion of the soil from the beginning of the natural program. The length of time required for this process is directly related to the intensity of conventional management practices that are currently employed or have been employed in the past.

The goal of a natural turf management program is to create athletic turf that meets aesthetic site objectives and playability, while eliminating toxic and synthetic chemical inputs that may have adverse impacts on health and the environment. The products and program are designed to utilize materials and adopt cultural practices that will avoid problems associated with runoff or leaching of nutrients and pest control products into water bodies and groundwater.

This approach will build a soil environment rich in microbiology that produces strong, healthy turf that is able to withstand many of the stresses that affect turfgrass. The natural turf system is better able to withstand pressures from heavy usage, insects, weeds, and disease, as well as drought and heat stress, as long as good cultural practices continue to be followed and products are chosen to enhance and continually address the soil biomass. While problems can arise in any turf system, they will be easier to alleviate with a soil that is healthy, with the proper microbiology in place.

There are two distinctly different types turf areas that present themselves for the development of a transition program. The first is the turf system that has been managed aggressively with synthetic fertilizers and regular applications of chemical control products. There is generally an unhealthy soil present, that is, a soil where biological life has been compromised by product use. The use of high levels of synthetic nitrogen and chemical control products usually creates a turf system that is relatively weed free and aggressively growing. The second is what we refer to as "organic by neglect". This is the area where little has been done in the way of inputs and cultural practices. Soils generally exhibit good health, but weeds may have been allowed to move in as a result of a lack of vigorous turf grass growth. Grass is struggling in places and weeds could become an issue.

Site and Management Analysis

This report provides supporting information for the development and implementation of a natural turf management program. The soil background, products, and cultural practices that are discussed all contribute to the underlying objective of creating a healthy turf system. A series of preventive steps once in place allow the system to stand up to insect, weed, and disease pressures, controlling problems before they arise. Included is descriptive information of current expectations and practices employed at the site, a site analysis, and specific recommendations.

Section 1
Site Photographs & Analysis 10/20/2011

The following pictures show the field as it appeared in mid October 2011. From a distance much of the field seems to be in fair condition. As you look through the pictures, it becomes evident that there are serious issues present.

- The grass area is 134,350 square feet.
- Turf density is only fair. The bluegrass that was part of the original sod has largely died off.
- There are large voids. The uniformity of the field is poor. The turf has a very clumpy appearance indicative of the fescues that remain.
- Judging by the blade appearance of the fescue grasses present (very wide and coarse), we can make the assumption that it is lacking in appropriate nutrients. The sod farm has told us that the fescues are the newer hybrid turf type tall fescues. It is these grasses that were specified in construction documents, as opposed to the older tall fescues. This should be confirmed to be the case. When hybrid turf types do not receive proper nutrients, specifically nitrogen, they can revert to their coarse-bladed "parents".
- There is exposed plastic netting evident. It is used at the sod farm to keep this type of sod from tearing when it is harvested young or when there is not a sufficient percentage of bluegrass present to knit the sod together.
- There are substantial wear areas at the goals. They are not just in the area of the goal, but rather quite extensive at the ends of the field. The southwest goal is really one large bare area encompassing substantial square footage. The northeast goal is quite worn and thin, but not as severely so.
- The site visit was after a rain event and there was evidence of poor drainage. There was standing water in places.
- It was apparent that drainage was an issue as the last picture shows the crusted slime layer created as a result of anaerobic conditions. This would not be created from just a single event, but rather from prolonged excess moisture in the root zone.
- Visual inspection and feel indicate that the soil was amended with sand, but not organic matter. Soil tests will substantiate this.
- Soil was collected and sent to the respective labs for analysis.

Section 2
Soil Test Reports & Analysis

The soil tests from both 2009 (pre-construction) and 2011 (post-construction) are included on the following pages. It is by comparison of the Nutrient and Textural Analyses that we can determine what may or may not have been done. There is a full explanation of the nutrient, textural, and biological components of the soil on the following pages.

Nutrient and Textural Analysis

- Calcium and Magnesium are the same. It is unclear whether lime was added, as it would be the Ca or Mg that would elevate the pH.
- The pH is within the desired range.
- Organic matter is .5% lower than in 2009.
- Cation exchange capacity (CEC) is substantially lower than 2009 (10 .5 in 2009 and 7.6 in 2011). This means the nutrient retention capability has been reduced by roughly 25%. This is most likely due to the addition of sand and the corresponding reduction of organic matter as a result of dilution. This is an indicator that compost was not added in the proper amount if at all.
- Potassium has been elevated to the desired range.
- Sand is now at 65%. This was the target goal.
- Both nitrate nitrogen (NO3-) and ammonium nitrogen (NH4+) are very low.

Soil Foodweb Analysis (bioassay of the living portion of the soil)

- Total bacterial numbers are excellent.
- Active bacterial numbers are excellent.
- Total fungal numbers are good.
- Active fungal numbers are excellent.
- Protozoa are low. There are not enough protozoa present to feed on bacteria and make nitrogen available. We need an inoculum that can be introduced with compost. It will also help to improve soil structure. This will provide greater support to the biomass.
- Total nematodes are low. An inoculum will address this.
- Mycorrihizal colonization is low. An inoculum introduced with seed will address this. There were synthetic fertilizer applications made by the contractor and once by the DPW (10-10-10 application). These are most likely responsible for these low numbers. As we permanently switch to organic inputs this will change.
- Active to total bacteria is low. We need to get more of it active and working. Horticultural molasses will address this. The potential is there.
- Active to total fungi is low. We need to get more active and working. Humic acid will address this.
- Both of the relationships of fungal to bacterial need to be improved. The soil is currently too bacterial and becoming more so. Strategies will be employed to address this relationship.
- The plant available nitrogen supply through the biomass is very low. This will improve as organic matter is addressed and the necessary balancing of the biomass gets underway.
- This test should be repeated next fall.

rt Number: 11-299-0507
unt Number: 65030

www.aleastern.com

A&L Eastern Laboratories, Inc.

7621 Whitepine Road Richmond, Virginia 23237 (804) 743-9401 Fax (804) 271-6446

Send To: NORTH COUNTRY ORGANICS
POB 372
BRADFORD VT 05033

2011

Grower:
CHIP OSBORNE
781-254-7862

Farm ID:

SOIL ANALYSIS REPORT

Analytical Method(s):
Mehlich 3; Morgan P

Received: 10/26/2011 **Date Of Analysis:** 10/27/2011 **Date Of Report:** 10/28/2011

le ID ID	Lab Number	Organic Matter			Phosphorus				Potassium		Magnesium		Calcium		Sodium		pH		Acidity	C.E.
		%	Rate	ENR lbs/A	Morgan P ppm	Rate	Reserve ppm	Rate	K ppm	Rate	Mg ppm	Rate	Ca ppm	Rate	Na ppm	Rate	Soil pH	Buffer Index	H meq/100g	meq/1
.EWOOD	07502	3.6	M	89	8	H			129	H	169	H	1071	H	28	VL	6.7	6.90	0.3	7.6

le ID ID	Percent Base Saturation					Nitrate		Sulfur		Zinc		Manganese		Iron		Copper		Boron		Soluble Salts		Chloride		Alumin
	K %	Mg %	Ca %	Na %	H %	NO_3N ppm	Rate	S ppm	Rate	Zn ppm	Rate	Mn ppm	Rate	Fe ppm	Rate	Cu ppm	Rate	B ppm	Rate	SS ms/cm	Rate	Cl ppm	Rate	Al ppm
.EWOOD	4.4	18.5	70.5	1.6	4.5	10		11	L	4.2	H	83	VH	228	VH	5.4	VH	0.6	M	0.2	VL			25

on this report represent the plant available nutrients in the ting after each value: VL (Very Low), L (Low), M (Medium),), VH (Very High). ENR - Estimated Nitrogen Release. - Cation Exchange Capacity.

Explanation of symbols: % (percent), ppm (parts per million), lbs/A (pounds per acre), ms/cm (milli-mhos per centimeter), meq/100g (milli-equivalent per 100 grams). Conversions: ppm x 2 = lbs/A, Soluble Salts ms/cm x 640 = ppm.

This report applies to sample(s) tested. Samples are retained a maximum of thirty days after testing.

Analysis prepared by: A&L Eastern Laboratories, Inc.

by: Pauric McGroary

Pauric McGroary

A&L Eastern Laboratories, Inc. 2011

7621 Whitepine Road Richmond, Virginia 23237 (804) 743-9401 Fax (804) 271-6446

www.aleastern.com

TEXTURE ANALYSIS

Client :	Grower :	Report No : 11-299-0507
NORTH COUNTRY ORGANICS	CHIP OSBORNE	Cust No : 65030
POB 372	781-254-7862	Date Printed : 10/28/2011
		Page : 1 of 1
BRADFORD, VT 05033		
	Farm:	Date Received : 10/26/2011

Lab No	Field ID	Sample Identification	Percent Sand	Percent Silt	Percent Clay	Textural Classification
07502		MAPLEWOOD	64.8	22.4	12.8	Sandy Loam

Soil 2011
Foodweb Analysis

leport prepared for:
)sborne Organics
:hip Osborne
1 Laurel Street
Marblehead, Massachusettes 0
781) 639-8702
zflor@aol.com

Report Sent:
Sample#: 03-009094 | Submission:03-004072
Unique ID: Maplewood
Plant: turf
Invoice Number: 0
Sample Received: 10/25/2011

For interpretation of this report please contact:
Local Advisor: or regional lab
Soil Foodweb New Yo
soilfoodwebny@aol.co
631-750-1553
Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacterial (µg/g)	Total Bacterial (µg/g)	Active Fungal (µg/g)	Total Fungal (µg/g)	Hyphal Diameter (µm)
Results	0.820	55.2	462	26.5	289	2.75
Comments	In Good Range	Excellent	Excellent	Excellent	Good	
:xpected Range Low	0.45	1	175	1	175	
High	0.85	5	300	5	300	

	Protozoa Numbers/g			Total Nematodes #/g	Percent Mycorrhizal Colonization	
	Flagellates	Amoebae	Ciliates		ENDO	ECTO
Results	**563**	**3399**	**17**	**5.57**	**15%**	**0%**
Comments	Low	Low	Low	Low	Low	Low
:xpected Range Low	5000	5000	50	10	40%	40%
High			100	20	80%	80%

Organism Biomass Ratios	Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply (lbs/acre)
Results	**0.63**	**0.09**	**0.12**	**0.48**	<25
Comments	Low	Low	Low	Low	
:xpected Range Low	0.8	0.15	0.15	0.75	
High	1.5	0.2	0.2	1.5	

Nematodes per Gram of Soil
Identification to genus

Bacterial Feeders	
Achromadora	0.23
Plectus	0.91
Rhabditidae	0.45
Tripyla	0.23
Fungal Feeders	
Thornia	0.34
Fungal/Root Feeders	
Bitylenchus	2.38

1645 Washington Ave. Bohemia, NY 11716 USA
631-750-1553 | soilfoodwebny@aol.com
www.soilfoodweb.com

03-009094: Page 1 of :

)sborne Organics
:hip Osborne
1 Laurel Street
Marblehead, Massachusettes 0
781) 639-8702
zflor@aol.com

Report Sent: 2011
Sample#: 03-009094 | Submission:03-004072
Unique ID: Maplewood
Plant: turf
Invoice Number: 0
Sample Received: 10/25/2011

For interpretation of this report please contact:
Local Advisor: or regional lab
Soil Foodweb New Yo
soilfoodwebny@aol.co
631-750-1553
Consulting fees may apply

Dry Weight:	Good soil moisture content.
Active Bacteria:	Bacterial activity above expected levels; Bacterial biomass will increase as long as nutrients are available.
Total Bacteria:	Higher than normal bacterial biomass suggests high bacterial species diversity.
Active Fungi:	Fungal activity above expected levels; fungal biomass will increase as long as nutrients are available.
Total Fungi:	The fungal biomass is in good range, but needs to be increased in relation to the bacterial biomass.
Hyphal Diameter:	Good fungal community is present.
Protozoa:	All protozoa numbers are low. Nutrients will not be cycled in high enough amounts for the healthy growth of turf. Inoculate protozoa with compost, compost teas or other inoculum. Improve soil structure to create a better environment for the proliferation of protozoa.
Total Nematodes:	Low numbers, and limited diversity. Root-feeding nematodes are present. Need to add beneficial nematodes (including predatory nematodes), improve conditions to allow their survival.
Mycorrhizal Col.:	Mycorrhizal colonization of roots too low. Add an inoculum of mycorrhizal spores, then provide humic acids to feed mycorrhizal fungi and improve colonization. Reduce any inorganic fertilizer apps.
TF/TB:	The soil is too bacterial for the best health of turf. Inoculate beneficial fungi to balance with bacterial biomass, and add fungal foods.
AF/TF:	Good balance of activity and total biomass for plant group, season.
AB/TB:	Good bacterial activity.
AF/AB:	Soil is bacterial dominated, and becoming more bacterial. A source of fungal inoculum and fungal foods are needed.
Nitrogen Supply:	Low plant available N supply from predators.

nterpretation Comments:
The soil is too bacterial for the best health of turf. Apply a compost dusting this fall to provide needed predatory microbes and improve diversity of the bacteria and fungi. Follow up with a granular humate at 2-3 lbs/1000 sq ft.
Begin a tea program in the spring with added balanced microbial foods. Routine teas should be applied through the growing season.

Soil Type: Sand, low organic matter, Plant: turf

Section 3
Scope of Work Analysis

Background
In 2009 Osborne Organics was asked to offer an opinion on the renovation of the multi-purpose sports field at DeHart Park. Rutgers and CHA were also involved. The original soil tests that were taken at that time are included in this report as a point of comparison. Specific recommendations were made regarding balancing soil chemistry, adjusting pH, improving organic matter content, increasing the sand percentage, and an choosing an appropriate grass mixture.

Those recommendations were:
The existing soil should be engineered to create a sandy loam with roughly 60% to 65% sand content
The pH should be adjusted within the 6.5 to 7.0 range
Organic matter should be amended to 6.0% to 7.5%
Turf Type Tall Fescue with Kentucky bluegrass should be the grass of choice

Analysis of Project Manual as it relates to soil and grass

The Project Manual created by CHA and dated September 24, 2009 was examined. The specifications, as they relate to soils, grasses, and related protocols, as put forth in that document were compared to the current soil tests and visual inspection of the field. Below are excerpts from the manual.

Section 02530 Turf Grass Installation for Sport Fields
Part 2 Products
2.1 Materials
C. Grass Materials
1. Sod: Provide machine-cut, strongly rooted, certified turf grass sod, at least 2 years old and free of weeds, non-organic contaminants and undesirable native grasses. Provide sod capable of vigorous growth and development when planted (viable, not dormant) and complying with the following requirements:

a. Type: 80% Tall Fescue (with three or more approved sports turf cultivars), 20% Bluegrass (with three or more approved turf type cultivars).

b. Sod Pad Size: Uniform thickness of 1 inch, plus or minus 1/8 inch, measured at time of cutting and excluding top growth and thatch. Provide turf in rolls that measure a minimum of 4 feet wide (no seam) and 30 feet in length. Broken or torn pads with uneven ends are not acceptable. Nylon netting not permitted.

c. Sod Strength: Provide pads capable of supporting their own weight and retaining size and shape when supplier's standard size pad is suspended vertically from a firm grasp on upper 10 percent of the pad.

d. Grown on a sand based soil (Loamy Sand or Sandy Loam with a minimum 70% sand). Sod grown on any other soil type is not allowed. Submit AALA testing certifying particle size analysis of sod growing source.

CHA included a section of supplemental information to bidders that was not part of the construction documents. Within that section is a document from Hummel & Co., Inc, a nationally recognized turf consulting company. For fine turf areas they recommend topsoil with organic matter content of 4 to 8% and note that the soils on site were slightly within or just below this range. They talk of amending the existing soils with sand at a 1:1 ratio and note that when properly done the organic matter content will be diluted by the sand. They go on to say that it will be important that a high quality compost be added to achieve an organic matter content in the soil of at least 4% by weight, but preferably 6 to 8%.

From the CHA Construction Documents
Section 02913 Amended Topsoil for Athletic Fields
Summary

- "Topsoil shall be on-site topsoil amended with approximately 1 part sand for 1 part topsoil as required by soil testing results."
- "Material proposed for use as topsoil must be stockpiled, sampled, and tested by the Testing Laboratory prior to use."
- "Acceptance of topsoil shall be based upon test results. Tested topsoil must be approved in writing by the Owner's representative before any material is used."
- "The soil shall contain not less than 4% or more than 8% by weight of decayed organic matter."
- "Contractor shall provide laboratory testing results for all compost to be delivered to the site. The testing shall include a "bioassay" to determine quality and maturity of all compost."

Analysis of Work Performed by Turco Golf

- It is apparent that sod with plastic mesh was used.
- In conversation with the sod company, we were told that they were not informed that the sod was to be used for the construction of an athletic field.
- It is questionable as to whether or not the sod was grown with "Tall Fescue (with three or more approved sports turf cultivars), 20% Bluegrass (with three or more approved turf type cultivars)".
- The sod did not meet the requirements set forth above regarding sod strength. It is my understanding that the contractor has said that he began using the mesh grown material when the first rolls began breaking apart and ripping during installation.
- This leads us to one of two conclusions. Either the sod was not two years old as required, or it was not the type of Fescue that is grown for sports turf, but rather for a golf course rough. It is the 20% Kentucky bluegrass that was mandated as part of the seed mixture that allows the grass to knit together and become a durable sod. There is very little bluegrass present at this time. Either it has died off due to post installation management or the percentage was not correct from the beginning. Another project that we just completed used the same sod that was mandated here. There was absolutely no ripping or tearing during installation.
- Specific fertilizer schedules were outlined for the contracting company to follow while they cared for the field post construction. There has been no documentation that they actually followed the program outlined by CHA. There are no post construction documents that have been provided as to the procedures that were actually followed. Currently the grass does not exhibit good nutritional availability and looking at the overall condition nutrition has probably been inadequate since early on.
- Sand was incorporated as required. The sand percentage was increased by 10 to 15%.

- The average organic matter percentage, based on soil testing, prior to construction in 2009 was 4.10%.
- The average organic matter percentage currently is 3.45%.
- CHA's Project Manual called for organic matter from 4 to 8% as recommended by Hummel. They did not mandate the Hummel recommendation of 6 to 8%.
- It is clear that the topsoil on site does not meet the minimum requirements for organic matter as mandated, but the values are only slightly below the minimum outlined in the documents. They are substantially below the "recommended" range.
- The contractor should be required to submit all soil and compost testing documents that were required at the time, along with the volume of material used to amend the soil.

Analysis of maintenance work performed in 2011

The program for 2011 was proposed as follows:

May 22	Dynamic Duo Microbe Inoculation
June 27	Dynamic Duo
	Fiesta Herbicide Spray
	Core Aerating
	Seeding
August 10	Dynamic Duo
	Growth Control
October 1	Dynamic Duo

- The first application was completed as scheduled.
- The second was skipped, apparently due to miscommunication.
- The third application was done on August 8.
- The fourth was not done on October 1. The contractor wanted to do the application on October 31. We requested that this application not take place as the field was too wet and that date was really too late for this type of fertilization to be effective.
- There was no rate of application noted.
- It appears that no regular program of aeration was put in place. One-time aeration for a heavily used sports field is insufficient.
- A spray application of Fiesta should not be part of a regularly scheduled program, but rather used if needed as a rescue treatment.

Dynamic Duo is a Nutrients Plus fertilizer product. The fundamental problem with this material is that much of the nutrient is derived from biosolids (sewerage sludge). We want to stay away from that type of material in an organic program. It is used by some contractors because it is less expensive than the legitimately organic forms of nitrogen.

The above program is flawed in that it calls for a fertilizer application in early August. That is right in the middle of the window when no nitrogen of any kind should be applied to turf. Nitrogen at that point in the season when temperatures are warm stimulates the growth of grass. Because our cool-season grasses do not photosynthesize efficiently in warm weather, the grass plant uses carbohydrate reserves to sustain growth, but can't replenish them.

Section 4
Recommendations, Program, Costs

Turf Decline

The bare and worn areas of the field should not be as extensive as they are at the sixteen-month point. There are several reasons that may or may not have contributed to this.

- The sod was not two years old as required and therefore did not have the strength and durability necessary to get a good start.
- There was not the required percentage of Kentucky bluegrass in the sod. It is the Kentucky bluegrass that knits together and fills bare spots. The Fescues are clump-forming grasses. They are what remain on the field.
- Athletic play was allowed on the field too soon after installation.
- Athletic play may or may not have been allowed on rainy days or too soon after a heavy rain event. We know that the field holds water and does not appear to drain rapidly. It is difficult to say whether this is attributed to the slope of the sub-grade or the compacted soil. One of the critical strategies we will recommend will be regular aeration. This may help address this.
- Regular aerations were not performed once athletic play commenced. Compaction can destroy the grass and root system quickly.
- Nitrogen levels were too low to support vigorous growth.
- Fertilizer applications were limited and not consistent.

Overall Recommendations

1. The plastic mesh is most certainly a safety hazard. It is clearly in violation of the contract. The strength of the initial sod that was tearing is also a question to be addressed. The Project Manual is specific regarding the criteria that needed to be met regarding sod strength. At the least, the contractor should be required to replace the sod grown with mesh and repair the worn areas.
2. A request should be made to determine exactly what species of turf grass made up the seed mixture for the sod. Further, we recommend asking about specific cultivars (varieties). The Project Manual was specific in that at least three cultivars of each species be used.
3. Documentation should be requested to determine whether the soil on site was amended with compost. The contractor was required to submit test data. We would recommend that invoices and test results be requested.
4. A specific list of all material inputs, complete with dates, rates, and specimen labels should be requested. This means any fertilizers, herbicides, or other material inputs put down post-construction by the contractor. This information will help to complete the site history and allow us to seamlessly begin the transition process.
5. There is an estimate on the next page from Viersma & Sons, Inc. to perform a core aeration and compost topdress. It is expensive. The rate of compost (1 cubic yard/1000 square feet) was his recommendation. We generally recommend less, somewhere between ½ to ¾ cubic yard/1000 square feet. His proposal is dated November 30, but I received it later than that. This process is not one that must be done now. The same benefit would be realized doing it early in the spring. The cost would be reduced by $4000 to $5000 if the rate of compost applied were reduced.

Perhaps an approach would be to perform the deep tine aeration now and address the topdressing in early spring along with the spring aeration, to coincide with the sod replacement.

6. Adopt and begin a complete natural turf management program that addresses all of the needs of the soil and turf grass in Spring 2012. Along with material inputs, aggressive over-seeding should become the focus of the program. These two aspects will then be combined with good horticultural practices, including multiple aerations annually. This will become the foundation upon which a management plan is created. The overall program may be adjusted in subsequent years when necessary, as we move the field through the transition period. This might be to address a particular concern or simply to reduce material inputs and take advantage of cost reductions as the field approaches sustainability (refer to the Cost Comparison Section 12).
7. A Level 1 program will be presented for the initial transition period. As discussion and follow-up to this report takes place, the issue of budget should be discussed. Together, we can determine the best approach to fit the program to the resources available. It is important to remember that the cost of the program will ultimately be determined in how it is implemented. There is not just one organic program. We will put forth what we believe is the best approach to address the overall site expectations and objectives. This will be complete with material costs at wholesale. This would provide actual costs if the work was to be done in-house. If work is to be outsourced, the cost would then reflect labor and markup on product and would be determined on how aggressively the bidding contractor approaches the RFP. One option that we have used successfully when outsourcing, is for the municipality to purchase all of the materials and put out an RFP for labor only. This keeps costs down.
8. Restrict use of the field when weather conditions are such that Field Capacity, as it relates to soil moisture, is exceeded. Play on a wet field, especially one that suffers from compaction, will cause damage that many times becomes permanent. Adopt a policy of “Red Flagging”. This is a practice that many school districts and municipalities use to protect their investment and the playability of the field. A person or persons is/are charged with the responsibility of making the decision to close the field should weather conditions dictate.
9. Limit play during the Spring of 2012 to allow seed and sod to become established.

a division of Bob Viersma & Sons, Inc.
PO Box 224
Allamuchy, NJ 07820
Tel: (908) 852-0552 Fax: (908) 852-0259

THE VIERSMA COMPANIES

Date:	Proposal Number:
November 30, 2011	AAS-11-204

email address: mike@viersma.com

Proposal To:	Project Description:
Township of Maplewood C/O Osborne Organics Attn: Chip Osborne	Deep Core Aeration and Topdressing Work for athletic fields at park in Maplewood.

Phone Number:	Email Address	Fax Number:	Cell Number:
	bzflor@aol.com		781-254-1484

Item Description	Quantity	U/M	Price	Amount
Deep tine aeration of new athletic fields at park in Maplewood utilizing 1-1/4" coring tines, maximum depth of 6-inches.	140,000	square feet	0.020	$2,800.00
Tine Charge for 1-1/4" x 10" deep coring tines.	12	each	42.50	$510.00
Topdress athletic fields w/ Topdressing mix - Includes 2 tractors. (maximum application rate of ~ 0.5 ton/1,000 sf or ~1 cy/1,000 sf)	140,000	square feet	0.0400	$5,600.00
Ag Choice Humus Compost Field Topdressing screened to 3/8"	140	cubic yards	33.00	$4,620.00

PAYMENT TO BE MADE AS FOLLOWS: Signed PO prior to start of work, Net 30 Days from Date of Invoice upon completion.	Sub-Total: Sales Tax: NJ Exempt	$13,530.00 $0.00
We Propose hereby to furnish material and labor-complete in accordance with specifications as outlined above, for the sum of:	Grand Total:	$13,530.00

Notes: 1. Prices based on quantities listed above, if the service area is reduced rates may need to be adjusted (bulk rate applied). 2. Additional charges may be incurred if excessive rock is encountered and depth of aeration may need to be adjusted due to rock. 3. Underground utilities such as irrigation and site lighting shall be painted and flagged prior to our arrival. 4. Not responsible for any damage to underground utilities such as irrigation and site lighting which are not clearly marked. 5. The cost to replace or modify the existing irrigation system is not included. 6. Additional charges may be incurred if debris including rocks and other buried material are brought up during aeration and need to be removed/disposed of. 7. Topdressing includes 2 tractors, 1 tractor equipped with a 6.5 cubic yard topdresser and the 2nd for loading. 8. The cost to topdress is based on the application rate indicated and all the topdressing material stockpiled adjacent or in close proximity to the fields prior to the start of work. Additional time may be needed if the topdressing material can not be stockpiled adjacent to the fields prior to the start of work.

All material is guaranteed to be as specified. All work to be completed in a workmanlike manner according to standard practices. Any alteration or deviation from above specifications involving extra costs will be executed only upon written orders, and will become an extra charge over and above the estimate. All agreements contingent upon strikes, accidents or delays beyond our control. Our workers are fully covered by Workers Compensation Insurance	Authorized Signature: Michael G Viersma Note: This proposal may withdrawn by us if not accepted within 30 Days.
Acceptance of Proposal – The above prices, specifications and conditions are satisfactory and are hereby accepted. Customer agrees to pay a finance charge of 1.5% per month (18% per Annum) on any past due amount not paid within 30 days of date of invoice and to pay collection costs, including reasonable attorney fees after default by the customer. Payment will be made as outline above. You are authorized to do the work as specified.	Signature: _____ Name/Title: _____ Date:

Annual Program Years 1 & 2

Early April Core aerate in 4 directions to achieve 7 to 10% impact on the field. Core diameter should not be less than ¾".
Fertilize at a rate of ¾ lb N/1000 square feet with a phosphorus-free natural organic fertilizer such as Renaissance 6-0-6, which is a soy and sulfate of potash blend.
Topdress with well-aged compost at a rate of ¾ cubic yard/1000 square feet. Testing should be required.
Apply granular humate at a rate of 3 lbs/1000 square feet to address the fungal biomass. The best product for this is Hum-Amend.
Slit seed all areas where sod has not been replaced. A seed blend of Perennial ryegrasses, known as Tri-Rye, should be used at this time to quickly fill bare areas before weeds move in. Seed at a rate of 9 lbs/1000 square feet.

June 15 Core aerate same as above.
Fertilize as above. Use the same product and rate.
Slit seed all areas including new sod. Use a 50% Kentucky bluegrass, 50% Perennial ryegrass seed mixture. Seed at a rate of 5 lbs/1000 square feet.

July 15 Spray application of actively aerated compost tea at a rate of 1 gallon/1000 square feet. To the spray tank add horticultural molasses (Nature's Wisdom) and fish hydrolysate (Mega Green) at individual rates of 10 ounces/1000 square feet.

September 1 Core aerate as above.
Fertilize with Renaissance 6-0-1 at a rate of 1lb N/1000 square feet
Topdress same as above if budget allows. This second application is the beginning of trying to correct the deficiency in organic matter as a result of the contractor not properly addressing it during construction.
Overseed with the same seed and rate as June.

October 1 Fertilize with Renaissance 6-0-1 at a rate of ½ lb N/1000 square feet.

November 1 Core aerate as above.

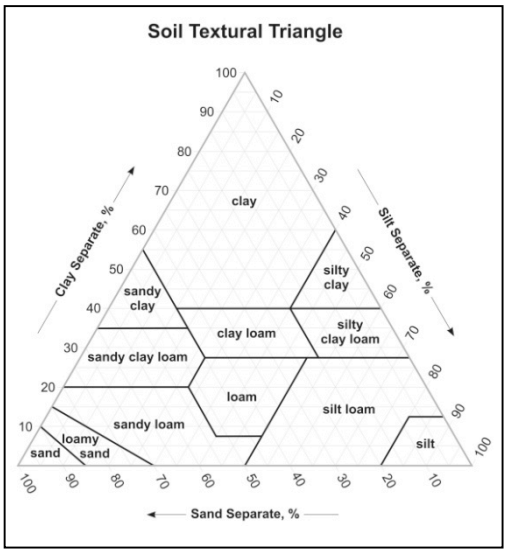
Calibrate and set irrigation system to properly water at each season.
Set schedule and protocol for proper mowing practices.

Detailed costs are being prepared in advance of a January meeting. Calls have been placed to product suppliers to get an estimate of 2012 prices. They should be available shortly after the first of the year. Service providers in your area are being sought to get an average cost for labor to implement the program. With this information we will be able to get a good idea of what cost will be to implement the program either in-house, outsourced, or a combination of both.

Section 5
Soil Texture

Soil is the foundation of our landscape. It is much more than just a functional medium to hold turfgrass and other plants upright. Soil is comprised of sand, silt, and clay mixed with varying amounts of organic matter, water, and air. The soil is very much alive. It is home to a microbial community that is made up of organisms both large and small. It is these microbes that give the soil its life. Ideal soils are typically described as having the following characteristics: 45% mineral, 25% air, 25% percent water, and 5% organic matter on average.

All soil particles, from the microscopic sheets of clay to the largest grains of sand, should be surrounded on all sides by air. When soils have varying degrees of moisture, the water occupies the air space. The air and water portion is also referred to as pore space; therefore, only one-half of healthy soil is solid particulate matter. The organic matter portion of the soil is where we concentrate our efforts in natural turf management, as it is the home to the soil microbiology.



Topsoil, as the name implies, is the uppermost layer of soil. This surface layer of soil is usually darker than subsoil because of the accumulation of organic matter. In different parts of the United States we see very different depths of topsoil. It can range from six to eight inches in the Northeast to two feet in the Midwest. Loam, on the other hand, is a textural classification. Texture refers to the relative amounts of sand, silt, and clay. A Loam is technically a soil with between 7% and 27% clay, 28% and 50% silt, and less than 52% sand. The term Loam can then be modified to Sandy Loam, Sandy Clay Loam, Clay Loam, Silty Clay Loam, or Silt Loam as the individual soil fractions change. The original soil on site was a Loam and it has been amended to a sandy Loam.

The USDA Textural Triangle is the tool we use to determine soil textural classifications. After testing determines the relative percentages of sand, silt, and clay, we refer to the Triangle and find the percentages on each side and follow the lines to the intersecting point.

Sands

Sands are loose and single-grained (that is, not aggregated together). They feel gritty to the touch and are not sticky. Each individual sand grain is of sufficient size that it can easily be seen and felt. Sands cannot be formed into a cast by squeezing when dry. When moist, sands will form a very weak cast, as if molded by the hand that crumbles when touched. Soil materials that are classified as sands must contain 85-100% sand-sized particles, 0-15% silt-sized particles, and 0-10% clay-sized particles. The reason that sands are referred to in the plural is that there are several USDA textures within this group. All of these textures fit the “sand” portion of the textural triangle, but they differ from each other in their relative proportions of the various sizes of sand grains. Sands are sieved to five sub classes; very fine, fine, medium, coarse, and very course.

Silt
Silt is similar to silt loam but contains even less sand and clay. Sand-sized particles, if present, are generally so small (either fine or very fine sand) that they are non-detectable to the fingers. Clay particles are present in such low percentages that little or no stickiness is imparted to the soil when moistened, but it instead feels smooth and rather silky. A handful of silt-sized particles can feel like flour, are somewhat plastic, and casts can be formed that will bear careful handling.

Clay
Clay is the finest textured of all the soil classes. Clay is actually a microscopic "sheet" as opposed to a particle like a sand grain. There is far greater surface area to a sheet of clay as opposed to a grain of sand. Clay usually forms extremely hard clods or lumps when dry and is extremely sticky and plastic when wet. When containing the proper amount of moisture, it can be "ribboned out" to a remarkable degree by squeezing between the thumb and forefinger, and may be rolled into a long, very thin wire. Clay holds moisture and does not grain well, and it has the tendency to compact easily.

Textural Analysis Results
A&L Eastern Laboratories, Inc.

% Sand	% Silt	% Clay	Textural Class
64.8	22.4	12.8	Sandy Loam

Section 6
Soil Chemistry Basics

pH
The first and probably most important area of attention is the relative acidity (or alkalinity) of the soil. It is measured as pH. The pH scale runs from 1.0 to 14.0 with 7.0 being neutral. The cool-season (C3) turfgrasses prefer a pH in the 6.5 to 7.0 range. Establishment of the pH within this range is important to the success of a natural management program. The macro-nutrients that the grass plant uses are most readily available when the pH is within this range. The grass plant uses nitrogen in the largest amount, followed by potassium, and then phosphorus. When the pH is substantially below this range, there is a smaller amount of nutrient available to the grass plant. The most important and critical first step in a natural program is to adjust the pH to the desired range. Unless the pH is close to the 6.5 to 7.0 range, the grass plant does not get the nutrients it needs with any degree of efficiency. Fertilizer can be repeatedly applied, but will have less than the maximum desired benefit.

The pH is well within the target range for the grasses present on site. There is no lime required at this time. In fact, once a natural turf program is fully in place, we would expect to see a natural buffering of the soil to take place, and it would be unlikely that the pH would ever drop. The following discussion of liming is solely for informational purposes.

Lime is used as the preferred input for raising the pH. The calcium to magnesium ratio, as determined by soil testing, is considered when determining the type of lime to be used (calcitic or dolomitic). The guidelines we follow call for a 7:1 to 8:1 calcium to magnesium ratio. Calcitic lime is used for a specific purpose; it is higher in calcium and low in magnesium. It is somewhat more expensive than dolomitic lime, which has higher magnesium levels, but it will elevate the pH while raising calcium levels.

It is suggested to adhere to the generally accepted practice of not exceeding 50 pounds of lime per 1,000 square feet of turf in any one application. Recommendations for applications greater than 50 pounds will be split between spring and fall. Raising the pH is not a process that happens rapidly. It can take up to 100 days for lime to break down and begin to elevate the pH. Products that are sold as soluble calcium to raise pH should be avoided. We are not after a quick change in the pH, but rather a sustained movement toward a slightly acid soil. The highly water-soluble products can be rendered less effective with heavy rains in the weeks following an application.

The pH adjustment is a critical first step in a sound turf management program, conventional or natural. As described above, unless the pH is established within the desired range, the nutrients we apply simply cannot be used efficiently, resulting in wasted money.

The establishment of the proper pH by liming is usually an expense occurred in the first years of a natural program. Natural fertilizers do not tend to acidify the soil in the way conventional products do after repeated applications. One of the benefits of natural fertilizers and composts that are used to "feed the soil" is a gradual natural buffering of the soil within the biomass and as that happens, pH becomes stable in the desired range.

Nutrient Management

An approach using primarily synthetic, water-soluble fertilizers is directly "feeding" the grass plant. These products are broken down by soil moisture and are readily available to the plant. Natural organic fertilizers work in a different way. It is the soil microbiology that breaks down the fertilizer and uses it as a food source. The microbes then make the nutrients available to the grass plant in a plant available form. It is this "feed the soil" approach that will be the basis for our recommendations on a nutrient program. In a natural program we do not focus on pounds of N in quite the same way as we do in conventional programs. A healthy soil, where the microbes are nourished with natural fertilizers, has the ability to cycle up to 2 lbs N to the grass plant on a monthly basis. This plateau is reached when sustainability is approached, generally three to four years into a complete natural turf management program.

All nutrient and cultural recommendations that are made will ultimately affect the microbes. They are a big part of creating and achieving good soil health and quality. This is really the starting point. Paying close attention to the soil, both soil chemistry and soil biology, is important in the transition process. There is a period of time involved in taking turf from a conventional program or an incomplete program (pH not established, etc.) to a natural one. That length of time varies with each different field or property. The process begins at this, the most basic, level.

Abbreviations

N	nitrogen
P	phosphorus
K	potassium
Ca	calcium
Mg	magnesium
ENR	estimated nitrogen release
CEC	action exchange capacity
PH	measure of acidity

Organic Matter (OM) and Cation Exchange Capacity (CEC)

■ **Organic Matter** makes up a relatively small fraction of the soil. A typical agricultural soil has between 1% and 6% organic matter. A soil that supports turfgrass should have between 5% and 7% organic matter. Organic matter has a tremendous effect on most soil properties. Think of organic matter as the home for the microbial community that makes the system function.

OM is made up of living organisms, fresh residues, and well-decomposed residues. These three components of organic matter have been referred to as the living, the dead, and the very dead (Magdoff, University of Vermont). The living portion is comprised of a wide variety of microorganisms, including bacteria, fungi, protozoa, and nematodes among others. Also included are plant roots, earthworms, insects, and larger animals that spend time in the soil. This living portion represents about 15% of total organic matter. The fresh residues, or the dead portion, are comprised of recently deceased microorganisms, insects, earthworms, and compost if applied as a topdress. The dead portion also includes crop or plant residues, in the case of a turfgrass system, grass clippings left on the turf, that are decomposed by saprophytes. Nutrient cycling happens here in the dead portion of OM. The very dead part of OM is humus. Humus is the end product of decomposition or the living and dead portions that ultimately can decompose no further. Humus is fully stable and is considered to be a long-term soil resource lasting many hundreds of years.

Humus is one of the central components that tie together the interrelated functions of soil chemistry, texture, and biology. As we begin to address and enrich soil organic matter, we are improving the humus content of the soil and all of the interactions that take place. When we get all of these aspects working in harmony, we begin to achieve what is now referred to as soil health. Conventional soil science has looked at soil chemistry, texture, and biology separately. The emerging way of looking at soil is to try to achieve optimum levels in each of these areas, as best we can, and the result is referred to as soil quality or soil health. Many natural fertilizers are now including humates as part of the blend for the specific purpose of working to create a healthy soil. If not included in a fertilizer blend, humates can be applied separately in granular or liquid form.

■ **Cation Exchange Capacity** is a measure of the nutrient holding capacity of the soil. It is reported on a soil test as meq/100g. The clay and humus (stabilized OM) portions of the soil contain negatively charged ions that attract and hold on to plus charged cations (nutrients). Older, well-aged OM (humus) contains the largest percentage of exchange sites. There are different clays that make up the soil profile, montmorillonite clays and kaolinite clays, and they each have different characteristics with regard to possessing the ions to attract nutrients. We can look at different soil samples and see results that seem

to contradict other results from the same general property, but most often the variable is that some soils are not native to the site, but rather brought in as topsoil to supplement existing soil on site.

Calcium (Ca), magnesium (Mg), potassium (K), hydrogen (H), aluminum (Al), and ammonium nitrogen (HN4+) are all attracted to the exchange sites as + charged nutrients. As CEC increases, so does the amount of retention. Any given soil can hold only as much + charged nutrients as the CEC will allow. Very sandy soils, low in clay percentage and organic matter, do not have the ability to retain much. When retention and availability is low, we need to attempt to create more exchange sites. The addition of clay to existing soil is not a practical solution. We can, however, improve organic matter and therefore humus with the appropriate inputs.

When a lot of hydrogen is held on the exchange sites, it contributes to soil acidity. Aluminum becomes soluble in acid soils. Turfgrass does not like soluble aluminum. We then apply lime in the form of calcium or magnesium, depending on the Ca:Mg ratio as determined by the Nutrient Analysis, to replace the hydrogen on the sites and elevate the pH.

As the process of mineralization (discussed in a future section) converts the organic source of nitrogen to the inorganic forms (nitrate, NO3- and ammonium, NH4+), the ammonium is held on the exchange site due to the + charge. The nitrate has the – charge, therefore it is repelled.

Nutrient Analysis

Rutgers Soil Testing Laboratory
New Brunswick, NJ

Sample	pH	OM %	Ca:Mg	P ppm	K ppm	Mg ppm	Ca ppm
	6.7	3.6	6 : 1	8	129	169	1071

Red indicates deficiency

Section 7
The Soil Biomass and Microorganisms

Any discussion of nutrient management in a natural turf program would be incomplete if the soil biomass was not addressed. It is really the foundation upon which our nutrient program is based. In taking a "feed the soil" approach, soil microbes are at the heart of our management strategy. It is the natural, organic fertilizer that is broken down by the microbial life and nutrients are made plant available. Synthetic fertilizers by their nature, and with high salt content, compromise the activity of much of this life in the soil. The microbes do not reproduce and function at healthy levels in soils that exhibit high salinity.

During the transition period from a conventional fertility management program to a natural one, it is important to address the role of the microbial community and choose products that science has shown enhance their development and function. The soil environment, specifically the OM, is the home for soil microbial life. The processes that take place in the microbial community are extremely complex, but at the most basic level it is a predatory relationship. The organisms are really just competing for survival. Their existence depends on an aerobic soil of good texture, chemistry, and fertility. As a result of one organism consuming another, nutrients, particularly carbon and nitrogen, are released. The nitrogen is in a plant available form that is ready to be taken up by the roots of the grass plant and the carbon is a soil energy resource.

During photosynthesis, sugars and carbohydrates are produced as "food" for the plant. Some of these carbohydrates become exudates. That is, they are exuded from the root system of the grass plant to the soil in the area of the rhizosphere. Bacteria and mychorrizal fungi in particular, are nourished by these exudates. That is why greater microbial colonization of the roots of grasses takes place. We do not see the same level of colonization on the roots of most broadleaf weeds. While this is an over-simplification of the process, in is in reality how it works.

It is the ability of the microbes to make the conversion from natural organic sources of N to the inorganic N that allows natural fertility to work. The organic N from natural fertilization or OM is converted to inorganic ammonium N by bacteria in the process of mineralization. It is also converted to nitrate N during the process of nitrification. Nitrate N has a negative charge and is therefore soluble. It relatively quickly moves to the root zone of the grass plants after it has been released from the bodies of the predator organisms. Ammonium N has a positive charge and is therefore held to some degree on the cation exchange sites and is referred to as reserve N. As higher-level predators consume the bacteria, the N is then released in a plant available form. Higher-level successional plants, like high production C3 grasses, use equal amounts of nitrate and ammonium. Many of the conventional, water-soluble fertilizers deliver most of the nitrogen as nitrate. This really isn't the way the grass prefers it and stress can be the result. A natural fertility program strives to work with nature and avoid this.

When we design a fertility program that is based on natural, organic fertilizer product, we also include materials that support and maintain a healthy soil and microbial community. Compost and compost teas are two of there materials. There are also microbial inoculants, liquid fish hydrolysates, seaweed, molasses, and humates that directly affect the health of the soil and its community of organisms in a positive way.

Section 8
Managing the Biomass with Compost Tea, Compost, and Humates

- **Compost tea** is the application that directly addresses the introduction of large numbers of microbes to the soil environment. The benefits are many, especially during transition. At the present time there are some contractors that can provide this service, but there are not many. We are working within the industry to change that. The most cost efficient approach to compost tea production is an in-house setup. It involves an investment in extracting/brewing and spray equipment.

Compost tea is one of the inputs on the horizon that will change the way we deal with several of the management aspects of growing high quality turfgrass in the backyard, on park and athletic fields, campuses, or on commercial and institutional properties. It is already being used to some extent, and over the next few years will become one of the foundations of a complete natural program. We now use the application of a compost topdress to address the organic matter content of the soil as well as to introduce beneficial soil biology and a plant available nutrient source. The application of a topdress typically adds costs in the beginning of the program, depending on the compost supplier and freight costs. When we have reached our target goal of organic matter percentage, the topdress applications can be reduced or eliminated, except when doing a major over-seeding.

In a turf system, we generally do not see the rapid depletion of organic matter the way we might expect in other areas of agricultural production. Compost tea, although valuable from the beginning of a natural management program, becomes especially important when topdress applications are reduced or eliminated. We rely on the compost tea to supply the microorganisms and all of the benefits that come with them. Compost tea does not directly add organic matter to the soil in the way compost does, but because our organic matter has reached our target level, we get along with increased biology only.

Exactly what it is compost tea and how it is actually made? Compost tea is a liquid extract of high-grade compost. More specifically, compost tea is a concentrated solution of microbial life produced by extracting beneficial microbes from vermi-compost (worm castings) or high-grade windrowed compost. When compost for tea stock is brought in from a different geographic region, it is important that a handful of soil or compost from the primary site or sites be added to the stock to introduce native organisms.

We suspend compost in a type of “tea bag” in gently agitating, de-chlorinated water. Different types of pumps that not only move water, but also infuse the water with oxygen provide the agitation. This aspect is critical as the process of extracting and brewing needs to be done in an aerobic environment. This is critical in order to sustain the life of some of the species of microbes that are being extracted. It is the gently agitating water that actually extracts the microbes. They are separated from the compost during this phase of the process. We now have a water solution that contains the same number of organisms that were in the compost. This process takes about two hours. We then could use this extraction to apply as a spray or soil drench.

If we take this extraction, feed the organisms in it, and grow them to a very large number over a twenty-four period, we then have a material known as actively aerated compost tea. This is called brewing. To the water we add materials like molasses, humic acid, fish hydrolysate, kelp/seaweed, flours, straw, and others to feed the organisms to facilitate their growth. There are parameters that need to be observed regarding water temperature, levels of dissolved oxygen in the water, and specific ratios of food sources

to water and compost. The quality, diversity, and number of the extracted organisms are directly related to the quality of the compost

Why is this solution an important asset for the turf manager? Aside from simply delivering large quantities of active biology to the soil profile, it does considerably more for us. It is a source of soil and foliar nutrients. They are delivered in a biologically available form for both plant and microbial uptake. The beneficial microbiology will compete with disease causing organisms and most times out-compete them, thereby suppressing a pathogen or disease problem before it gets to a point when turf damage occurs. The microbes have the ability to degrade and break down toxic materials and pesticides, they produce essential plant growth hormones, and they can fix nitrogen and mineralize plant available nutrients.

As we introduce compost tea to the turf system, we begin to create a biologically active soil profile. As the soil continually becomes more alive, we see direct and lasting benefits to the turfgrass. When a healthy, balanced soil profile with the proper biology to sustain turfgrass is in place, we see benefits in the nutritional area, whereby the nutritional health and quality of the plant is improved as well as the soil's ability to retain nitrogen and other nutrients like calcium, potassium, and phosphorus. We also create a condition in the soil that embraces beneficial biology and its ability to suppress disease causing and pest organisms.

Lastly, we are improving and creating good soil structure that increases water infiltration, oxygen diffusion, and the water holding capacity of the soil. The benefits are many, and when the availability of compost tea becomes more prevalent, it will become one of the tools every turf manager will use. One of the attractive aspects of compost tea for the turf manager will be the relatively low cost. At a rate of roughly 20 to 25 gallons or more to the acre, it will be a very economical way to take natural turf management to the next level. There was a time when spray equipment in the hands of the turf manager meant a pesticide application was imminent. Times are changing and that stigma will soon disappear.

- **Humates** are metal (mineral) salts of humic or fulvic acids. Humus is a highly stable by-product of organic matter decomposition. Humic acid is the most biologically active component of soil humus. The humus portion of the soil is relatively small. The organic matter percentage generally ranges from 3% to 8% with an optimum level in a turf system in the 6% to 7% range. Humus makes up 65% to 75% of the total organic matter. Humus plays an important role as a component of soil fertility. Its impact is far greater proportionally than the percentage of the soil mass that it makes up. The molecules of humus are not rapidly degraded by microorganisms as many non-humic substances are. Humus is, in fact, slow to decompose, and when found in combination with soil minerals can persist for several hundred years.

With the emergence of conventional, synthetic N P K (nitrogen, phosphorus, an potassium) fertilizers, we (in turf management and agriculture) lost sight of the natural order of soil management. When it was discovered that the synthetics had the ability to rapidly stimulate plant growth, the turf industry was born and jumped on the bandwagon. The prolonged use of synthetic products, which adversely affects health and the environment, has led to many soil problems associated with soil quality destruction.

Humic substances that would be considered to be "fertilizer grade" are obtained from carbon containing mineral deposits in many parts of the world. Here in the United States there are several mines and deposits that contain good agricultural grade humic substances.

Naturally occurring humic substances from low-grade lignites and leonardites (nature's soil conditioners), are superior fertilizer ingredients. A major source of humic substances for fertilizer use is from leonardites. Leonardite is defined as a highly oxidized low-grade lignite that contains a relatively high concentration of fulvic acids.

Humates, suitable for both granular and liquid applications, are readily available and can be purchased from a variety of sources. They can be purchased by themselves or as part of a proprietary blend of materials. The application of these products to a turf system is addressing the soil health and quality at its most basic level.

Some benefits include:

Builds healthy soil
Increased organic matter that helps to reduce N loss through leaching
Contains carbon as an energy source for microbes
Improves soil structure, aggregation, water infiltration, aeration, and water-holding capacity
Increases nutrient availability to the grass plant
Facilitates mineral breakdown
Increases microbial activity
Helps with root growth and penetration, and chlorophyll density

- **Compost** and composting is a complex subject. It is far more than just creating a pile of organic matter and watching it turn into a soil-like material. Composting is an exacting science when we want to produce a finished product of high quality. This discussion is intended to provide an overview of product and process, and in no way should be thought to impart all of the information necessary to fully understand the subject.

Compost is the product of an aerobic process, whereby microorganisms break down and decompose various forms of organic matter. The organic matter is referred to as feedstock or substrate, and this can be made from a wide range of materials. The feedstock can be random materials, or they can be chosen to meet a particular recipe. When we compost by recipe, we start by choosing materials that generally follow a 20:1 to 30:1 carbon to nitrogen ratio on the input side with a desired goal of mature compost being in the range of 12:1 to 20:1. The microorganisms use the material as a food source throughout the decomposition process.

The microorganisms contribute to a process that produces heat, carbon dioxide, water vapor, and humus. Humus is a highly stable by-product of the decomposition process. It can make up 60% of finished compost. The process also stabilizes nutrients and pH, giving us a finished material rich in nutrients and microbial life, a high percentage of humus and organic matter, and close to neutral pH, making this an ideal soil amendment and topdress material for established turfgrass.

Composting is done at the municipal level in many areas as well as in the private sector. Composters are generally required in most states to conform to guidelines that deal with health issues, but at the present time there are no national standards that deal with compost quality. You need to have a good understanding of the criteria that define compost quality and rely on your own assessment that should include proper testing. Whenever possible you should obtain information from the supplier to support the quality of the compost. There are two tests that are done on compost. One is compost chemistry

that tells us organic matter, moisture content, and retained nutrients. The other is a bio-assay that details the organisms present in the compost.

Very briefly, compost quality is determined by several criteria. The finished material should have no offensive odor, there should be no recognizable remnants of the original feedstock, and it should be mature. Maturity can best be determined by biological testing. There are four phases to the composting process: (i) Mesophilic, (ii) Thermophilic, (iii) Cooling (second mesophilic), and (iv) Maturity. These phases have specific temperature ranges associated with them. There are different populations of microorganisms present at each phase. The Maturation Phase can best be determined by testing which determines the microorganisms present.

Immature compost would be considered to be a product of inferior quality. It has not yet successfully completed the process. It can, in fact, be very detrimental to a turf system and can cause turf damage. Once the composting process has begun, it naturally wants to complete itself. Immature compost will pull N from the soil to try to complete the process, resulting in a yellowing of the turf. As the N levels drop, chlorophyll production in the grass plant decreases, resulting in a plant that no longer has the resources necessary to undergo photosynthesis at a satisfactory level. As photosynthesis decreases, carbohydrate production drops off and the turf weakens.

Compost as a topdress in a turf system does four things for us. (i) It helps to increase soil organic matter. When we are dealing with low OM percentages topdressing is the preferred practice for addressing the deficiency. This practice in itself gives good results, but when we can combine topdressing with cultivation (core aeration) the benefit is magnified because the compost is able to fall into the core holes and reach the root zone. (ii) When a compost application is combined with over-seeding, it enhances germination and establishment. Think of it as creating a seed-bed to receive the grass seed, not unlike a seed starting mix we might use to grow a tray of tomato seedlings for transplant. (iii) Compost, by virtue of its neutral pH and healthy microbial population, has the ability to help buffer the soil and counteract naturally acidic soils without the use of lime. (iv) During the ongoing decomposition process, we experience nutrient release and get good greening of the turf, much the same way we do with a fertilizer application.

Compost is not a fertilizer, but in fact it is the microbial population that makes the nitrogen available to the grass plant. Lastly, it is the beneficial microbes in compost, particularly fungi that give the grass what has been referred to as acquired immune resistance. The beneficial fungi have the ability to fight and suppress many fungal pathogens, and disease issues in turf become easier to address.

Topdressing with sand or a blend of primarily sand with 20% to 30% compost added will not give the same benefits as a high quality compost. The conventional industry uses the sand-based material, but natural programs are based on compost. Sand is used at times in our program for very specific purposes, but not as a general topdress.

Application rates for compost topdressing are generally in the range of 1/2 to 3/4 cubic yard/1000 square feet. You may hear of recommended rates of 1 cubic yard/1000 square feet, but that is on the heavy side. The depth of material should be between 1/4” and 3/8”. If the depth approaches 1/2,” it is too heavy an application.

- **Topdressing** can be done at any time during the growing season. After application, the material breaks down and is assimilated into the turf within a matter of days. We do need a relatively short

window when the field or grass area is not being used. This is only because the compost might be "muddy" after rain or irrigation. The optimum times of the growing season for topdressing are early-spring, mid to late-June, September, and late-October/early-November. The June and September windows are ideal to combine topdressing and over-seeding. Seeding to fill bare spots and thicken turf can also be done with topdressing in early-spring. The late fall application is to "set the turf up" for spring. Topdressing should always be combined with cultivation.

A very exciting project that is being discussed at Lawrenceville is a multi-faceted composting program. Possibilities exist for both vermi and windrow composting. This is part of an overall green initiative. As a composting program progresses, the resulting material can be returned to campus grounds, both turf and landscape beds. The process can also produce material for a compost tea program.

Section 9
The Transition Period

When turf management programs change, there is a period of time we refer to as the transition period. When we move from a conventional program to a natural one, the length of time involved in transition is directly related to the intensity of current and past management practices and the overall turf quality.

During transition, it is important to address the soil, its biomass, and appropriate inputs as well as those cultural practices that support them and the turf itself. The biggest issue is moving the management of fertility (through the biomass) from a conventional program to a natural one. After many years of conventional fertility management that has used synthetic, water-soluble fertilizers with high salt levels, the soil microbiology has been bypassed and somewhat compromised. We will strive to support and restore the soil to good health during this transition period so that the natural processes of fertility will take over and produce healthy turf.

When a turf system is moved from a conventional to a natural program, we do not expect to see a collapse or failure. As long as the transition process addresses the whole system, including soil biomass, natural product, and cultural practices, we expect to see steady improvement.

The product discussed in this approach, other than lime and those associated with the cultural practices of cultivation and over-seeding, should remain constant for three years. At that point, sustainability will be achieved and a reassessment of the input requirements may be addressed.

It is important during this period that we establish a sound management plan that enables us to successfully move forward. The reality in the municipal sector is that there is not always budget money available in the amount desired or needed to implement any type of turf management program. In this approach, it is important to address the four P's -protocol, procedure, product, and prioritization. It is the concept of prioritization that allows us to create levels of management and then to allocate often scarce financial resources to those areas of properties where the greatest impact will be made. This is critical, especially in the transition period, when we need to be the most aggressive with inputs and cultural practices.

Section 10
Fertility and Turfgrass Nutrition

When we address fertility issues, it is important to look at the needs of the grass itself. Of the three major nutrients used by turfgrass, nitrogen is used in the largest amount. It is followed by potassium and then phosphorus. There are other nutrients, of course, but our primary focus is with these three. The three remaining of the six macro-nutrients used by turfgrasses are calcium, magnesium, and sulfur. In creating a nutrient budget for a turf system, we are basing it on nitrogen to be delivered in one form or another. The other nutrients may or may not be delivered as part of a fertilizer analysis or as a stand-alone amendment for corrective purposes.

When a turf area is used, as opposed to just "viewed," the turf is generally under some stress; grass plants get damaged and often cannot reproduce at a rapid enough rate to maintain maximum turf density. The recuperative capacity of the grass plants is governed by the genetic capabilities of individual species as well as nutrient availability. We need more available nutrient, specifically nitrogen, to sustain this type of turf system as opposed to what we might need for a residential lawn. Depending on the species of cool-season grass in a lawn, the system may not really want or need too much additional nitrogen. It is available nitrogen that directly stimulates growth. This does not mean that we necessarily need more fertilizer applications. A reasonable nutrient budget is in the 3 to 5 lb N range from all sources on an annual basis. This N is not all derived from fertilizer, but from a variety of sources including recycling grass clippings.

One of the basic differences between a natural program and a conventional one is that we do not get all of the nitrogen from fertilizer product alone. Nitrogen from fertilizer is important, but it is only a part. We acknowledge the contributory N from compost topdressing, liquid fertilizers, compost tea and humic substances, microbial inoculants, and grass clippings returned to the system. As we use product to initially improve soil health, we are building a system that will make N readily available naturally to the grass in the future. It is this concept that allows us to have healthy turf at a lower cost three years down the road.

We can use two kinds of fertilizer in our natural, organic nutrient management program, granular and liquid. The granular product may be made up of different sources of nutrient. The source of the nitrogen (the nutrient used in the largest amount by turfgrass) is in the organic form generally derived from either grain or animal by-products. The liquid product is a fish hydrolysate. There are also amino acid based materials that are being used and developed.

The difference between natural, organic fertilizers and conventional or synthetic fertilizers is simple. Synthetic fertilizer is inorganic. It is manufactured during a chemical process that produces for the most part a highly water-soluble fertilizer. Anhydrous ammonia is reacted under pressure and high temperatures. Urea is formed. It takes five ton of petroleum to produce one ton of urea. It breaks down on contact with soil moisture and is taken up by the grass plant very rapidly. This is why you see a "quick green-up" or burst of growth with these products. There is a way to coat or encapsulate the fertilizer to delay the breakdown. The fertilizer is taken up rapidly, works quickly, and then leaves the root zone. This process is directly feeding the grass plant. Most synthetic fertilizer programs call for numerous applications annually.

It is estimated that only thirty-five percent of the nitrogen makes a positive impact on the plant. Sixty-five percent is lost to leaching to groundwater or volatilization back to the atmosphere. This happens because the nitrogen in the water-soluble form is being released faster than the plant can assimilate it. It begins to work on contact with moisture within forty-eight hours, maximum release is at the seven to ten day point, and four to six weeks after application it is gone from the rhizosphere.

Synthetic fertilizers, being water-soluble, move rapidly through the soil and can be major contributors to non point source pollution. With natural, organic fertilizers this does not happen. Because the fertilizer is broken down by soil microbes and used as a food source, it is naturally slow release. The major portion of the nitrogen source is water-insoluble nitrogen (WIN) and breaks down over time supplying a slow steady food-source. It does not move through the soil and create the same type of problems as synthetic products do because the nutrients are closely held by the biomass.

Natural, organic fertilizer products work in a completely different way. Nature has put in place a system that makes nutrients available to plant material. A good example of this is a mature forest. No one fertilizes a forest, yet plant material grows and is healthy and adequately nourished. Other plant material functions in basically the same way, but because it is a closed system, we add fertilizer or compost topdress or soil incorporation to supply nutrients in the way that fallen leaves decompose and supply nutrients in a forest. Turfgrasses, managed as we do, have higher genetic requirements for N than nature can provide. That is why we fertilize, to some degree, our higher expectation turf. There are certainly situations where grass can be grown that need very little in the way of supplemental nutrition. We just need to follow the principle of “right plant-right place” when choosing a turfgrass specie for a particular use.

It is the microbial life in the soil that really makes nutrients available to our plants. Remember that in high school biology we learned that a handful of soil contains billions of mostly beneficial, living organisms that nature put in place for the sole purpose of growing plants. It is these organisms that in fact make the nutrients available. We are using natural, organic fertilizers to feed and nourish the microbes, so that they in turn, through a natural process, can make the nitrogen and other nutrients available to the plant. We are now actually feeding the soil. The nutrients in organic fertilizers are either plant, animal, or mineral based, with the nitrogen, as previously mentioned, derived from plant or animal sources. It is important to note that fertilizer is not plant food, but rather a catalyst that influences photosynthesis and other plant functions. It is the process of photosynthesis that produces carbohydrates and sugars. These are the “foods” that sustain the plant.

The nitrogen in natural, organic fertilizers is in the organic form. It is important to remember that plants can’t use organic forms of nitrogen, but rather they can only use it in the inorganic form. That is why synthetics work so rapidly. Natural fertilizers supply organic nitrogen to the microbes as a food source, and the microbes break it down and in turn release it to the plant in the inorganic form. The nitrogen is converted to the inorganic form (plant available form) of

ammonium during the process of mineralization and the nitrate form during the process of nitrification. Both of these processes are entirely dependent on a healthy, active microbial population. Grass prefers equal amounts of both. The ammonium is reserve nitrogen and the nitrate is soluble nitrogen. Unlike the synthetic fertilizer the soluble nitrate is not released rapidly, but little by little. This process avoids nitrogen runoff.

With so many different fertilizers and formulations on the market, it can be confusing trying to tell the difference between the products. As a rule, we can get an idea as to the type of fertilizer in the bag from the percentage of nitrogen in the analysis. The analysis is the three numbers on the bag that represent nitrogen, phosphorus, and potassium in that order. It is stated as a percentage of each nutrient in one hundred pounds of fertilizer. The reason that nitrogen is our benchmark is because it is the nutrient used in the largest amount by turfgrass. If the nitrogen number is less than ten or eleven, the product is most likely a natural, organic product. If the number is between thirteen and eighteen, it is probably have a bridge product. Bridge products are those that contain both synthetic and natural, organic sources of nitrogen. When the nitrogen percentage is greater than nineteen, the product is usually mostly synthetic.

We apply granular fertilizers at two general times of the year, spring and fall. Depending on site and soil conditions and the grass specie we may fertilize twice a year or it may be split into three, four, or more lower dose applications.

When we use the liquid fish hydrolysate as a fertilizer, we are using a relatively low dose of nitrogen. It is not the nitrogen that is of primary importance to us, but it is the proteins, enzymes, and amino acids preserved from the fish that directly nourish and stimulate the soil and in turn the grass. The grass gets an immediate benefit from the small percentage of nitrogen, but the greatest benefit is to the soil. We are building a healthy soil environment that will support healthy grass. This type of product is relatively low cost and with the right equipment fairly easy to apply. In a tight budget situation this product can be very cost effective.

Fertilizer Specifics

There are several natural organic fertilizers on the market with different analyses. They range from 4% to 12% N. There should be roughly 3/4 of the N in the WIN form and the balance will be natural water-soluble N. This addresses both short and long term N needs. My recommendation would be to use a natural fertilizer with roughly a 1:1 N to K ratio. Our goal is to move all of the properties to a no phosphorus fertilizer. The majority of sites tested can begin a no-phos program immediately. There are six sites where the use of phosphorus is warranted based on the soil tests. Recommended analyses are described elsewhere.

The percentage of N only matters when we are calculating the amount to use on a particular size property. The higher the N%, the smaller amount of product by weight we need to use. Simply put, we need twice as much fertilizer with 4% N as we do with a product that has 8% N and so on.

Section 11
Cultural Practices

Irrigation

Irrigation schedules on those properties that have systems in place can be set to match the soil conditions. Those properties, with higher clay percentages, will hold more water and for a longer time than the sandier soils. Irrigation is used on turf that has higher expectations. Appropriate available moisture on a regular basis allows grass the ability to stay out of complete dormancy during the high heat periods of the summer. We do not try to push the grass with water during the summer, just maintain it. It also ensures that certain soil inoculums succeed, grass seed can germinate and establish without fear of drought, and the grass can steadily grow and reproduce even in times of little rainfall.

We need to be aware of field capacity for each property. In terms of soil moisture, field capacity refers to the optimum amount of water that is held in the root zone of a particular soil. As previously discussed, the ideal soil profile is 45% mineral, 5% OM, 25% air, and 25% moisture. This means that a handful of soil contains 50% solid matter and the balance is pore space. When a turf system is irrigated to the point of saturation, either by rainfall or an irrigation system, the pore space becomes filled with water. After a period of time (variable depending on soil texture and compaction), the free water drains below the root zone and the remaining soil moisture is known as field capacity. As a general rule, irrigation systems should water to field capacity and not be run again until needed. They can be set to deliver different rates and lengths of time that correspond to the season of the year and general weather and growing conditions.

The best way to irrigate is to deliver enough water to provide a deep thorough watering. At times of over-seeding it is best to provide relatively frequent, shallow irrigation. We want the seed to stay as continually moist as possible without being overly wet.

Natural turf growing in sandy loam needs only one inch of water per week maximum and turf growing in a loam soil needs one-half to one inch weekly during the warmer periods of the growing season when going through the transition process. As soils become less sandy with increasing amounts of clay, soils have a greater tendency to compact. Compaction impedes drainage. In the cool-season regions of the country, the timeframe is usually mid-May to mid-September. Once a natural turf system is well underway, irrigation requirements drop to one inch per week during dry spells. Of course, those properties that do not have irrigation depend on natural rainfall. A natural turf system is better able to deal with dry spells and periods of minimal rainfall than a conventional system.

Cultivation

Compacted soil is the biggest enemy of turfgrass. Compaction favors weeds and discourages the growth of healthy grass. Turfgrass roots, as well as soil microbiology, are entirely dependent upon an aerobic soil environment. Aerobic soils are those soils with a reasonable amount of oxygen available.

When we talk about soil aggregation, we refer among other parameters, to a loose friable soil. All soil particles from the microscopic sheets of clay to the largest grains of sand should be surrounded on all sides by air. This is referred to as pore space. When soil becomes compacted by heavy use, athletic play, mowing and other equipment, or heavy rain or regular irrigation, the turfgrass begins to struggle and certain weeds proliferate. This is also the case with a fine textured soil that has a natural tendency to become compacted regardless of use. As the soil is compressed by mechanical means, the air portion of

the soil is eliminated, pore space is lost, and oxygen is lost. We now have particle touching particle with nowhere for the grass roots to grow.

The roots of the grass plant should be long and fibrous, whereas some of the broadleaf weeds have shorter, thicker root systems. When soils become very compacted, the grass plant's roots cannot penetrate and they alter themselves so that they can adapt and they become short and clubby. A short clubby root system on a grass plant severely restricts the plant's ability to absorb nutrients, and it becomes weakened. The broadleaf weed begins to thrive, because it has a root system that is easily adapted to these conditions. Prostrate knotweed, broadleaf plantain, and pineapple weed are three indicator weeds that are routinely found on compacted sports fields and other turf areas. All of these reproduce from seed so once fully established in sizable numbers, it takes some time to replace them with viable turf. The same is basically true in a conventional program.

The process to loosen the soil is cultivation. In a turfgrass system, the type of cultivation we employ is referred to as aerification. When we aerate a turf area, we are loosening the soil, introducing oxygen, and reestablishing pore space. There are different methods of aeration, the two most common being core and shatter tine aeration.

As a part of the overall process in addressing the grass at the sites, aerification is central to future successes for managing turf of higher expectations. Generally speaking, it is one of the least expensive things we can do, but it gives us the largest direct benefit. Kentucky bluegrass, Perennial ryegrass, and Fine and TTT fescues need to have an ample supply of oxygen available in the root-zone. Most of the microbes that we are nurturing are also oxygen dependent. When soils become increasingly compacted, turfgrass struggles. The process of deterioration in grass is such that bare and thin areas develop from wear because the grass is under multiple stresses and can't reproduce itself.

The wear could be on a sport's field, common area, or path (intended or otherwise). This type of situation best responds when the annual program is committed to repairing worn areas soon after they develop. Whether or not it is the delay in responding to the problem or the lack of financial commitment to the program to allow this attention, that leads to deteriorating grass, large bare areas, and weed encroachment. This is true in any type of program. This is not an issue of product type. Conventional programs use a variety of synthetic pesticides to kill, repel or mitigate a pest, usually a weed. It is important to understand that these materials do not grow grass. In the case of a weed, we now have a bare area where the weed was or would have been. If we do not proactively take steps to reestablish grass, the problem will get worse. At this point simple aeration and over-seeding alone usually can't successfully reestablish good turf density from seed while the field is in play or the area is being used.

Over-seeding

Turf density is a measure of the number of grass plants growing in one square foot of a turf area. When we come close to maximum density in a healthy soil, weeds begin to be suppressed. Regular over-seeding on an annual basis is the most effective strategy for keeping weed populations down. Broadleaf weeds will be out-competed by thick, healthy turf. Minimum turf density is an invitation for crabgrass and other weed pests. A bare spot the size of a silver dollar can potentially become a crabgrass issue. Over-seeding sport's turf is generally done more frequently than lawn areas.

When over-seeding is combined with a compost topdress application and either a core or shatter tine aerification, the germination and establishment phases both improve. These cultural practices should be combined whenever possible. Looser soil helps the new seedling and the soil from the cores resting on the surface provides a loose seedbed for the new seed.

Maintaining genetic diversity of cool-season grasses in a sports field is important. As we broaden the genetic base with newer cultivars, we are taking a proactive approach to potentially minimizing negative impacts of insect and disease pressures. We can take advantage of cultivars that contain natural endophytes (fungi that give some grasses resistance to surface grazing insects) and those that are bred to have disease resistance.

Over-seeding is a critical part of a successful natural program. Site use and seasonal considerations are always part of the decision making process when we over-seed.

There are different mixtures of cool-season grasses available for very different uses.. Different producers will suggest percentage mixtures. Different mixtures can be used for specific conditions and desired results at different times of the year. Again remember to select the right grass plant for the site.

Mowing

We should be looking at mowing heights in the 3" range overall. One of the principles behind this mowing height is that there is more blade surface exposed to the sun, and photosynthesis takes place more efficiently and to a greater degree. The C3 grasses (cool-season) are not efficient photosynthesizers. As mowing height increases, it helps to counter this. As photosynthesis increases, more carbohydrates (the real plant food) are produced and the grass gets stronger and healthier with substantially more food resources and energy reserves. There is also a greater amount of exudates entering the rhizosphere to nourish the biomass. There are very specific beneficial organisms that colonize the root system of the grass plants looking for these exudates. For every inch we increase mowing height we get a corresponding increase in carbohydrate production.

Height Effects on Leaf Area and Photosynthesis Capacity

Mowing Height	1"	2"	3"
Relative Change % in Photosynthesis	1.0	240	5760

Roberts 1992

In addition to the above advantage, the 3" blade height facilitates a good healthy root system. Deep probing roots are one of our goals. It is this deep root system that produces strong grass plants. The deep roots also bring the plant a measure of drought tolerance. The plant can draw on moisture deeper in the soil profile. As the grass plant gets stronger and the system increases in density, weeds begin to be suppressed. It is the thick turf and its response to N from nutrient cycling that allows it to reproduce itself rapidly.

Grass height on sport's turf is governed by ball roll. Generally speaking, the smaller the ball the shorter the grass. We take steps to accommodate this in our mowing practices.

Clippings should generally be left on the turf. If the proper practice of removing one-third of the blade at each cutting is followed, the fear of an unsightly lawn or field is not realized. There are a few cutting weeks in the spring when removal might be an option if shoot growth is rapid.

As fall approaches mowing heights can be reduced, because the threat of weed pressures lessen. As mowing heights become shorter in the fall, the grass plant still needs the surface area to photosynthesize, and it aggressively sends out tillers, stolons, or rhizomes to create it. As vertical extension is reduced, lateral extension increases. The net overall benefit is a thickening of the turf. Fall is the best time to experience success with seeding. Grass height should be reduced to 2" for fall over-seeding. The lower cut allows light to reach the soil surface and in turn it provides the energy needed for germination.