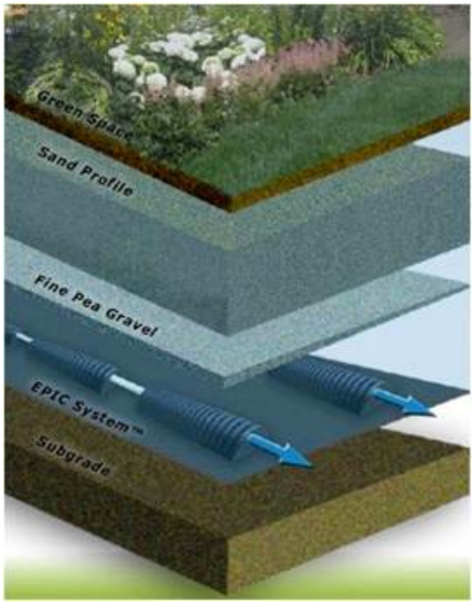


EPIC System Maintenance Manual

EPIC Maintenance Manual

PREFACE

This manual provides the general procedural process for EPIC system maintenance. It is not intended to cover all aspects or site specific applications of the continuous maintenance process which can vary between projects, climatic locations, and landscapes.

Unlike the complex world of pressurized sprinkler irrigation that deals with trenches, 24V wiring circuits, zone valves, and hardware with many moving parts; the Environmental Passive Integrated Chamber (EPIC™) System has no moving parts, is non-pressurized and primarily gravity driven. EPIC systems involve a unique, yet simple approach to landscape irrigation, drainage, and water management; distributing moisture reliably to the plant's root zone when operated correctly.

Good grass management has become, and is both an art and a science that not only involves nutrients but also mowing, aeration, thatching, awareness of disease, environmental factors, timing, and patience. There is not one successful formula for maintenance.

Every turf manager has their own experiences related to climatic conditions and environmental circumstances. Fertilizer manufacturers also provide their own special formulations and recommendations based on their research and experience. EPIC efficiently assists with the management of water, allowing your focus to be managing the turf.

THE EPIC PARADIGM SHIFT

Historically the same philosophy and practiced methods of water management have repeated since Joseph Smith patented the first swiveling lawn sprinkler in 1894. Fundamentally, all the different sprinkler brands and various part categories have remained the same, in principle, for over a century. Drip systems share the operational maintenance challenges of pressurized irrigation.

Trials addressed by every irrigation system are providing enough water to satisfy plant growth, while attempting to avoid water waste. Climate factors such as temperature, humidity, sun exposure, air ventilation / wind, leaf area all contribute to a plant's evapotranspiration (ET) rate. Advancements in irrigation system "improvements" include precise distribution patterns & timers, various sensors, controllers, even satellite imagery; complex technology to determine a "best guess" of water ET rates allocated for the plant.

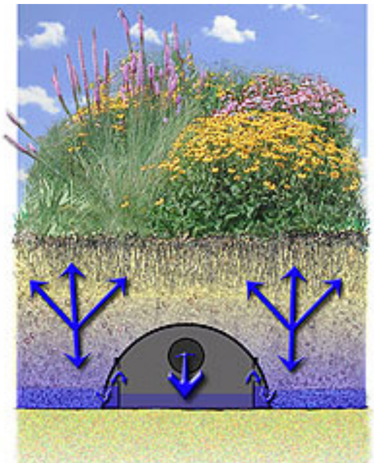
Conversely, the EPIC system philosophy trusts the plant itself to determine its own need, as nature intended. Scientific metered studies around the world continue to verify EPIC's 100% irrigation efficiency with zero waste, and 60%-80% reduction in water use compared to sprinklers or drip systems. Nearly every drop is conserved in EPIC as the Firestone EPDM liner prevents any water loss to the ground table or adjoining native soils. Multiple types of water sources may be blended and utilized in the EPIC System.

Figure - Roots of bean plant irrigated from the surface reveals the fast sheering effect that cuts at developing root hairs and damages the root system.

Typically, water absorption occurs at the roots of a plant. Therefore, the current practice of surface applications is inefficient. This results in wasteful practices including erosive runoff, environmental pollution, compacted soils, poor drainage, pressurized breakage / repairs, wind pattern loss, hard water stain calcification, surface evaporation and maintenance headaches. EPIC "capillary irrigation" utilizes basic science, founded in nature, to provide an aerobic and consistent moisture supply to the plant's root system.

Figure - Roots of an identical bean plant develop more root hairs and a stronger, more prolific root system from EPIC's method of slow moving, subsurface capillary irrigation.

EPIC SCIENCE | HOW IT WORKS



The science of EPIC utilizes particle characteristics of washed sand and water's unique cohesion and adhesion properties to distribute moisture between sand particles efficiently, even against gravity. Non-pressurized, low flow, and gravity driven, water seeks its own level by path of least resistance through the EPIC System in a three-dimensional flow; yielding non-clogging, filtered drainage, and sand hydroponic "capillary irrigation"; effectively achieving both irrigation and drainage without moving parts, on a13mm tolerance laser level subgrade. Depending on chamber density and outfall connections, EPIC can drain up to 26mm in 24 hours without endured surface pooling.

Analogous to cellular biology, EPIC functions as individual "cells" integrated into a "system," Interfaced to the bottom fine gravel layer (1-3mm) that bridges water distribution to the washed sand profile. Four Liters per minute inlet water fills the first EPIC chamber, and then spills to the 2nd, and the remaining sequence of chambers until the system is "charged." The sand mimics a sponge holding an average 100-200 Liters per square meter of surface area, depending on approved local aggregates characteristics which, in turn, determine a project's EPIC profile depth. The EPIC profile will absorb26mm of rain prior to any system drainage. Thus, EPIC landscapes additionally serve as storm water retention and reuse.

EPIC water management dynamics are integrated in two distinct zones unique in the EPIC profile.

EPIC Profile Zones

Capillary Zone

The sand profile area above the invert of the connecting pipes in the EPIC chamber is defined as the capillary zone. This zone is the biologically active zone as it simultaneously provides even and variable moisture distribution along with proportional oxygen content. This is where the roots grow, and the soil bacteria are active. This zone provides sand stability, and the zone that enhances biological filtration through adhesion. A combination of sand's capillary rise characteristic (obtained from testing) and intended use of the EPIC profile determine the design depth of the profile, the depth and location of the capillary zone.

Figure V - EPIC sand capillary zone above saturated zone

For example, in turf applications the design guidelines are to add 100mm to the height the sand will capillarize upwards in 24 hours. This then provides an adequate moisture level at the surface to allow for germination of seed and the lateral growth of rhizomes from turf grasses under normal operating levels.

Saturated Zone

The EPIC system creates a temporary 8 cm perched water table on top of the EPDM liner. The water spreads evenly through the bridging gravel and then is absorbed upward into the sand profile. In flat EPIC areas the height of the saturation zone can be adjusted by manipulating the "swing joint" elbow at the drain vault.

Water Management

Global precipitation is constant, distribution is variable. Either there is too much water and flooding, or too little fresh water and drought in any given area. EPIC systems vary design approach with solutions to accommodate both the "too dry, too wet" problems using fundamentally the same technology.

In dry climates water during brief periods of excess storm events is channeled to a secondary storage system for reuse. A 2.5cm rain event produces 2.5 L , EPIC areas capture and filter water for reuse as future irrigation water. Void spaces between sand particles total 100L per m² in a 38cm EPIC profile, and more than 120L per square meter in 60 cm profiles.

EPIC systems with established turf absorb rates of 25mm per hour continuously without surface pooling. Excess water can then drain into underground storage reservoirs for sustainable reuse. The water is bio-filtered for storage, or ground water recharge, without stagnation, algae growth or evaporation loss.

Some EPIC applications include storm water management, grey water reuse, erosion control, infiltration, grass parking and turf utility roads, agriculture, saline landscape irrigation; the list of EPIC's capabilities span a vast palette of liquid and air movement solutions.

WATER MANAGEMENT MAINTENANCE

Water management alone is not a guarantee of successful plant growth. Aeration, nutrient additions and various cultural practices all play a major part in this field's aesthetics.

Water needs of any plant divides into the two categories of *physical content* of water in the roots, stems, leaf structure tissue itself and water lost by *transpiration* of the plant.

Turf grasses provide minimal storage in structure but lose a lot of water thru transpiration. Transpiration is the invisible physical activity of growing plants where water absorbed at the root level is transferred through the supporting stems and out to the surrounding atmosphere from leaf openings called "stomata".

Turf grasses may transpire as little as 1 Liter per m² per day during cooler time periods, or possibly over 4 Liters per m² per day during hot, dry windy conditions. Water loss by transpiration is a variable rate that will be dependent on a combination of Plant species, Leaf area (of growing tissue), Humidity, Temperature, Wind speed, Sun exposure (cloudiness), and Health of the plant.

Grass does not waste water – people do.

Properly constructed EPIC™ Systems will match the transpiration needs of the plant by simply providing a stable underground reservoir, and the plants themselves determine the water uptake they need.

OPERATION

COMPONENTS

The sequential primary components of the EPIC™ System are:

Figure - EPIC sub-grade, EPDM liner, EPIC Chambers, finish

1) Laser level subgrade
2) Geotextile Felt Fabric
3) 45 mil Firestone EPDM Liner on subgrade and upright walls
4) EPIC Chambers w/ non-pressurized 60mm connectors
5) 51mm of washed bridging gravel or coarse sand
6) 55cm (+/-)clean dune sand (“sweet sand”)
7) Total average profile depth +/-55mm (varies upon approved EPIC aggregate sources)
8) Inlet | Inlet header pipe
9) Outlet | Drain header pipe | Observation ports
10) Reservoir assembly

INLET

The Inlet is the point of water introduction into the EPIC system. Recommend to locate EPIC inlets from project “as-built” plans, and routinely verify inlet rate(s). Due to friction loss, inlets the greatest distance & vertical lift away from the water pump may require a more open valve setting, compared to inlets closer to the pump, to maintain equal low-flow rates. EPIC chamber shall not exceed a flow rate of 8 L/Min. in connections from a single inlet.

Figure - Inlet vault with gate valve inlet from pump in reservoir

Figure- Inlet Header Pipe

INLET HEADER PIPE

Large athletic fields incorporate 15cm header pipes along the sideline with multiple inlets from the reservoir pump. The inlet flow of a typical field is adjusted between 8-14 Liters per minute per number of EPIC chamber row connections to the 15cm inlet header.

The recommended operating water level is at the mid-point of the 15cm inlet header and/or the 60mm connector pipe to the EPIC chamber. This allows for an efficient air displacement exchange through the EPIC system simultaneous to its irrigation cycles.

OUTLET

The Outlet of water leaving the EPIC system discharge into the tank reservoir or to secondary storage reservoirs as allocated in the "as-built" plans. A closed EPIC system has no outlet and continually recirculates the water. An open EPIC system has a final outlet from the reservoir, at capacity, to project outfall. Water elevation levels of the EPIC cell can be controlled by the adjustable union joint and elbow installed in the outlet vault.

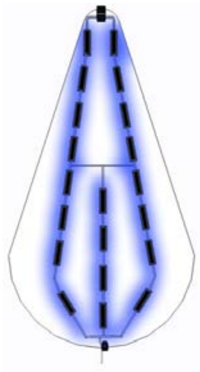
Figure- Concrete outlet vault with adjustable "swing joint" to control water elevation.

ZERO-DRAIN

A feature typical of EPIC designs in flat EPIC systems is a simple upgrade that provides more precise and immediate saturated zone water elevation adjustments. The zero drain option is installed in the last EPIC chamber of the flow pattern.

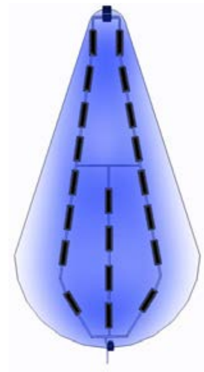
Figure- Zero Drain EPIC camber connection

Dig. 1: Filling EPIC™ System too fast



Drain

Dig. 2: Filling EPIC™ System correctly



Drain

- **Running the submersible pump too <u>long</u> (+24-48 hrs.) will not create a problem.**
- **Running the submersible pump too <u>often / frequent</u> can cause a problem; too much water will not allow the system to fluctuate water levels which is good for the exchange of O_2 & CO_2.**

At the end of an EPIC flow pattern is an observation drain vault to verify water has reached the entire length of each EPIC flow pattern. If the EPIC™ system is filled too fast (+12 Liters per minute) the water will quickly move from chamber to chamber and begin to come out the drain giving the impression that the system has been fully charged. In reality the system is barely charged because ample time was not given to allow the water to move laterally through the gravel layer and into the sand layer (Dig. 1). When ample time is given, as seen in (Dig. 2), the water will move laterally allowing for sufficient system charging.

The **EPIC™** System field is designed to require minimum maintenance of moisture levels. The only pressurized connections to the system are from the pump to the inlet units, otherwise the **EPIC™** System is gravity driven with no moving parts.

Irrigation Duty Cycle

Water levels must be "pulsed" weekly by "charging" EPIC with water to push out CO^2 and other respiration gases and the water recedes over time to draw in O^2. A typical irrigation cycle is 24 hours each week programmed by the adjustable electrical timer, which controls the electrical current to the water pump.

If the water supply pumps are not on long enough (24 hour ***minimum*** per cycle) the water may not reach the drain ports, potentially causing stressed areas of the turf furthest from the water inlets.

TANK RESERVOIR

Typical EPIC installations utilize a plastic tank reservoir or various capacity sizes. The Reservoir houses the Float Valve, Water Pump, and electrical / water supply.

SECONDARY STORAGE RESERVOIRS

Various secondary storage reservoirs can integrate with EPIC as an underground void space to hold, retain, reuse, and/or delay storm volumes ranging from thousands to millions of gallons and its potential erosive energy. Captured excess water is filtered through the EPIC sand profile prior to reservoir storage. Storage reservoirs may be lined with EPDM liner to retain water for reuse, or be unlined for ground infiltration.

Figure- Triton S-29 Chambers with EPDM liner

ACCESS COVERS

All electrical, pump, float valve are equipped with accessible cover or manhole as specified in plans. Routine monitoring of component operation and functionality during its duty cycle is recommended.

Figure - Reservoir access showing pump, float, & drain

FLOAT VALVE

Float valves shall operate within a pressure range of 103 – 792 kPa in conjunction with the water pump specified in accordance to the construction documents and plan set. Water flow through the float valve must be larger than the output rate of the submersible pump. Float valve shall have a quick connect union to retrieve if necessary as specified in plans.

WATER PUMP

Submersible water pump shall have quick connect union to retrieve pump if necessary as specified in plans.

Water & Electrical Supply

Pressurized water supply connections typically are a single point location in conjunction with the electrical supply that operates the recirculation pump. A dedicated 20 Amp 115V electrical circuit shall operate the submersible water pump positioned in the recirculation tank reservoir as specified in the plans.

function of an EPIC™ System sand profile.

In a given volume of medium-sized sand grains, approximately half of the space (50%) is occupied by the sand particles and the other half (50%) as void space. In the growing environment of an EPIC™ System profile this void space is a combination of water, air and growing plant tissue (roots). As capillary physics draws water upward from the saturated zone (area totally submerged with water) a graduated water concentration occurs within the profile. The closer to the water line the more saturated the sand. The further from the water line the drier the sand.

EPIC Holding capacity

The Normal **EPIC™** Water Operating Level is the midpoint of the 2" connection pipe between EPIC chambers. In the profile just above this water line the water content in the sand is approximately 85% and the remaining void space is 15%. The surface will feel damp and there is sufficient moisture to germinate seed and sustain turf grass.

If the water level is allowed to drop 90mm (the bottom of the liner) the moisture level at the surface may only be 3% water and 97% air. This allows air to enter the profile while moisture remains available held between sand particles. A given volume of sand has about 50% of its volume available as open space and 50% occupied by water or gases (air).

If the water supply is shut off, the volume of water will still be held by capillary adhesion and will slowly start to **dry out from the top down**. A typical EPIC system holds 120 L per m^2 of surface area. Shutting off the water supply in the **EPIC™** System will not produce an immediate drying affect and water will continue to be available to developed turf root structure.

In climates that have frequent rain events, it is possible that supplementary water may never need to be added. Rain water is harvested and stored, and only excess water is allowed to drain out of the system.

Routine Maintenance

A nutrient (fertilization) program is required and it will have a routine schedule attached to it. **Follow the routine even if the grass appears to be healthy**. The program balances out the sand, making nutrients available for future growth. Do not wait for the grass to look stressed before reaction, the formulas may be too little, too late, or even chemically overwhelming to already injured and stressed grass.

The fertility program for a sand-based field must be developed and implemented by the field manager.

Mowing of Turf

Figure 1: Sharp blade cut

Figure 2: Dull blade cut

Mow frequently and keep mower blades sharp. Grass grows from the bottom up constantly pushing the upper part the leaf blade upward. The cut ends of leaf blades are "open wounds" where plant diseases can take hold. Sharp mower blades make a clean "wound" while dull blades cause shredding and pulling of tissue thus increasing the damaged area.

Frequent mowing has four advantages:

- Cutting off a smaller portion of the upper grass blade means that the formerly damaged tissue from the last mowing is removed before diseases had time to establish in the "open wound"
- By removing a smaller portion of the leaf blade, most of the photosynthesis surface area remains intact thus the grass blade is less stressed
- Smaller cut portions fall down between the grass blades easier, decompose quicker and the field looks greener
- By not allowing the grass to stretch upward, grasses tend to respond by creating more shoots laterally providing denser, thicker turf.

Aeration

Aeration is critical to avoid formation of Black Plug Layer (BPL), a "capping" affect between the sand profile and the organic matter layer that is present in turf grass. This will result in **anaerobic** (oxygen deficient) conditions within the soil profile. This BPL affect will prevent the exchange of gases and infiltration of water in the fields sand profile which will result in a steady decline of turf quality.

The washed sands used in **EPIC™** profiles assure that pore space is always available for a certain amount of oxygen content. Oxygen is generally introduced into the profile from air pressure (21% oxygen) in the atmosphere above the surface, which then disperses into upper layers of the sand profile. Oxygen then combines with moisture films around individual sand grains, thus making it available to the root hairs.

Conversely, the respiration of roots in healthy growing plants and the biological activity of soil organisms in the soil produce carbon dioxide gas which must equalize itself with the carbon dioxide levels of air. While the carbon dioxide level in air is a mere 0.03 %, the sand content can be 5 % or more. Oxygen therefore is not only used up physically to form carbon dioxide, but is also displaced by the carbon dioxide concentrations. As such it is necessary to maintain an exchange pathway between the sand and the air above it so equalization can take place. This exchange pathway can be blocked or hindered by:

- Compacted clay soil
- Infrequent or lack of core aeration
- Tight plant thatch
- Rapidly decomposing organic material or dead grass
- Saturated soil conditions
- Sod that **has not** been cored **within several weeks** of being laid
- Lack of soil worm activity

AEROBIC CONDITIONS

Aerobic (oxygen sufficient) conditions must be available for respiration in roots, which in turn is necessary for plant growth. Experiments on numerous plants have shown that growth ceases when oxygen is removed by replacing it with another gas or water. The amount of oxygen necessary for growth varies with the species. Roots at great depths, in water logged soils or in very compact soils are likely to suffer from lack of oxygen.

Agronomic Overview

Nutrient Agronomy

Eight inorganic elements have been recognized as essential nutrients for plant growth, each with a specific function in plant physiology. The following table summarizes these eight and their function within plants. Washed sands are traditionally considered sterile environments but may contain some of the listed nutrients naturally as composition elements from their derivative rock. As such testing at a certified soil lab of the sand source will be required to determine which of the eight elements are missing or in need of replenishing.

Essential Element	Symbol	Plant usage
Calcium	Ca++	Calcium plays a prominent role in the absorption of other minerals from the soil. It neutralizes acids and has an antitoxic effect on other poisonous substances in the soil. Root hair cells contain calcium pectate, a colloid which enables it to imbibe water. This substance also forms the cementing material for holding all cells together, and is the first substance in the formation of new cell walls.
Iron	Fe+++	Iron is essential as part of the cytochrome oxidation system in respiration function. It is also essential for chlorophyll formation even though it is not part of the chlorophyll molecule. Many brown and reddish sands and soils may have an abundance of Iron, but it is not always in a form usable by the plant.
Magnesium	Mg++	Magnesium is a constituent of the chlorophyll molecule. Without chlorophyll there is no interaction with sunlight to produce plant tissue. However very high concentrations of magnesium are toxic to plants.
Manganese	Mn++	Manganese is thought to be necessary for the proper function of plant respiratory enzymes.

Nitrogen	NO_3^-	Nitrogen, only absorbed as a nitrate, is absolutely essential to growth, affecting particularly the growth of above ground parts. It is a constituent of chlorophyll, but is chiefly used for the production of proteins which are essential to every cell. A nitrogen deficiency quickly manifests itself as the yellowing of green foliage (chlorotic). Excess nitrogen may cause excessive vegetative growth which can result in weak and tender stems and foliage which are then susceptible to fungus and insect injury. Some nitrates are produced naturally through the interaction of lightning in thunderstorms; some is fixed by specialized soil bacteria living in nodules of specialized plants such as clover and alfalfa. Decomposition of dead organic material by soil organisms and their waste products (urea) may also provide nitrates through complex biological interactions. Urea → Ammonia→ Nitrites→ Nitrates. However, for lush thick turf, supplemental addition of nitrogen sources will almost always be necessary.
Potassium	K^+	Potassium is necessary for the proper carbohydrate metabolism of the plant. When potassium is deficient, storage organs such as roots, tubers, and seeds are small and shriveled. Plants with ample supply of potassium have been reported to be more resistant to disease and insect injury.
Phosphorus	$PO_4^{- - -}$	Phosphorus in the soil is most likely absorbed as a phosphate ion. It is essential for the formation of many compounds such as phosphoproteins and phospholipids. Lack of this element interferes with normal cell division and checks growth. It is important for proper functioning of photosynthesis and respiration. Phosphorus also increases root development and as such is important in the early stages of sod or seed growth.
Sulfur	$SO_4^{- -}$	Sulfur, absorbed as a sulfate ion, is a constituent of at least three amino acids that occur in proteins. Glutathione is an essential component in the respiration role of plants and the take up of oxygen.

SOIL ANALYSIS

Many regional and national soil testing and Agricultural Laboratories are available to assist owners that grow turf or crops. The installation of EPIC systems does not diminish the requirement to periodically obtain soil samples of the root zone to determine missing or excess elements involved with good vegetative growth. Routine sampling and record keeping with a reputable laboratory is a very valuable association.

Rely on testing and sound advice to establish the nutrient formula. Large athletic fields should as a matter of routine send in appropriate soil samples to agricultural labs at least annually, and preferably semiannual to determine what is missing and what supplement levels are needed. If storm or effluent water is used for irrigation an analysis is needed of the water as it will be a contributing factor in the mix. Nutrient levels and types cannot be seen and there are no simple field tests to get the information. Cost of these lab analyses is reasonable and provides a scientific base line data as to nutrient levels. Discuss the results and recommendations with an EPIC representative or EPIC Certified Contractor to formulate a routine.

Annual soil and water lab analysis is recommended to verify, chemically, the precise balance of nutrient supplements to apply to the turf for maximum aesthetics.

KEEP RECORDS AND BE OBSERVANT OF CHANGE.

Chronological records of chemical applications, formulas used, weather conditions, field usage and stress conditions with recovery times provide invaluable assessment data to deduct cause and affect relationships if challenges occur.

For example the start of a disease infestation a week after a visiting team's appearance may be related to disease introduction by contamination transfer from athletic cleats. Accurate data availability and subsequent review simplifies investigation and deduction of issues.

DISEASE

A disease can be defined as an abnormal condition of plants resulting from changes in their physiological processes and morphological development and caused be some adverse environmental factor (s). A disease is the end result of three factors occurring simultaneously:

1) A susceptible host (turf plant),

2) A pathogen capable of infecting the host

3) And environmental conditions that favor the development of disease.

The first indication that something might be wrong with the grass is the appearance of a brown (dead) patch of grass blades, or a patch that shows discoloration. A closer examination may also show that the brown grass blades feel dry and brittle. To zero in on the definitive causes will require a systematic approach that includes:

- closer observation
- literary references
- Process of deduction
- expert consultation
- laboratory microscopic examinations

To illustrate the complexity - a “brown” patch may be caused by:

Lack of moisture	**Too much moisture**	**Fertilizer spill**	**Chemical spill**	**Molds Over 17 species**
Deer urine Rabbit activity At night	**Pet urine Yours or visitor**	**Rodent activity Over 4 species**	**Insect activity Over a 100 species**	**Missing or Imbalance of Nutrients**
Mechanical damage	**Insufficient sunlight**	**Heat stress**	**Cold stress**	**A combination of more than one factor**

Turf Establishment

Establishment Period

Sand-based fields will initially require a more comprehensive fertility program. Most washed sands are initially nutrient poor in some elements necessary for good plant growth. These nutrients must be added to the sand profile. Daily periodic inspections must be performed to assure optimum moisture levels are maintained. The Establishment Period is the most critical step towards high quality turf grass.

Figure- Capillary rise witnessed at surface as level EPIC field is charged from inlet header to outlet header.

PREPARATION

- Smooth dry finish grade sand with drag mat
- Begin charging of all EPIC inlets
- Verify capillary irrigation moisture as reached all areas of each flow pattern
- Apply establishing fertilizer nutrients granules on surface

FIRST WEEK

- Keep the pump on 24/7 to maintain the EPIC water level at the maximum saturation level. This will reveal moisture within 25mm of the surface.

SECOND WEEK.

- Use a USGA Standard Sized Golf Cup Cutter or a soil probe to check root growth.
- Reduce pump inlet operation to EPIC system from 24/7 to 24/3.

THIRD WEEK.

- Root growth should be well established, the sod should not lift when pulled or tugged with hands.
- Use a USGA Standard Golf Cup Cutter or a soil probe to check root growth.
- After root growth reaches an average of 150mm reduce pump operation cycle to 24/2 (see below)
- Program the pump timer to be on for 24 hours, off for 72 hours, on for 24 hours, and off for 48 hours to complete the weekly cycle.
- Check the flow rates in the 15 inlet units
- Confirm flow of water reaches the 15 observation drain units

FOURTH WEEK.

- Mow new growth removing not more than 1/3 of the plants total height per mowing.
- Allow two (2) days resting time between mowing **(**standard practices until desired finish grass height is achieved.

SIXTH – EIGHTH WEEK.

- Core aeration operation of the field is recommended with a piston driven core aerator. **Aeration is critical** to avoid anaerobic conditions within the sand profile. An analogy would be laying a piece of plastic over the top of the field. This “capping” affect will prevent the exchange of gases and infiltration of water in the fields sand profile which will result in a steady decline of turf quality. A typical indication of anaerobic conditions is a BPL (Black Plug Layer) that is a grey – black color and smells like sulfur or “rotten eggs”.

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Time	Material/Procedure	Rationale
All months	**Maintain grass height to 20mm height or as recommended by sod grower for selected species**	**Mow at least once per week in the early and late months and twice per week during the peak growing season with a sharp mower. Mow in alternating patterns. If mowing is required more often to maintain the routine of mowing only one-third of the grass blade, schedule more mowings.**
All months	**Maintain adequate and proper moisture levels based on seasonal and daily weather fluctuations.**	**Normal operating level is operating the pump 24 hrs. / 1-2 times per week.**
All Months	**Fertility**	**Observe and test for fertility requirements, fertilize as needed from soil tests and visual plant inspections. *Sand-based fields will require a more comprehensive fertility program***
Seasonally	**Aeration** **Over seeding**	**Sand fields grow aggressively. Aeration is critical to keep airflow in and out of the system and avoid anaerobic conditions. A typical indication of anaerobic conditions is a BPL (Black Plug Layer) that is a grey – black color and smells like sulfur or "rotten eggs".** **Occasional overseeding may be required in high traffic areas. A key to successful overseeding is to get the seed down into the sand. This can be accomplished using a hollow tined aerator or slit seeder. NO overhead irrigation is required. Seeding right after aeration is recommended.**

Whether the source of the element and compound is derived naturally or artificially, if plants are to do their best, they must be supplied with a proper balance of all the essential inorganic substances. If any one of the inorganic substances is deficient, its lack will soon be manifested in the growth of the plant regardless of how much of all the other substances may be available.

Figure - Kentucky Blue Grass 30 days after seeding in ordinary sand.
(Left) No nutrients added (right) Addition of balanced nutrients

Research has alluded to importance of other factors as soil and water pH, Cation Exchange Capacity (CEC), Base saturation levels, Zinc and other trace elements etc. The latest trends are experimentation with microrhizomes, humic acid levels, and microbial density indexes (MDI).

PLANTINGS

TURF SEED

- Before seed is applied, owner must inspect the field. Seed shall not be applied until further settling is not apparent.
- Seed shall be applied with a mechanical device such as a Brillion Seed Drill with minimum58mm spacing. All applications must be in two directions, (90 degrees across) applying one half of the seed in each direction.

Figure - EPIC seed germination @ 8 days

- Apply1.4 kg of seed per 1,000m²
- In the event that there is washing or erosion from irrigation or rainfall, the Contractor shall reseed areas that are not uniform.
- EPIC system must be adjusted so that moisture is present in the top 6mm of the surface.

TURF SOD

Use only high quality sod of known genetic origin that is free of noxious weeds, disease, and insect problems. It should appear healthy and vigorous and should conform to the following:

Figure- Turf Sod at Westside Park, Los Angeles, CA

- Sod should have been grown in soil comprising at a minimum 85% sand, or bare rooted sod grown with soil less techniques.
- Sod should be machine cut at a uniform

depth of 13-51mm – excluding shoot growth and thatch.

- Sod should not have been cut in excessively wet or dry weather.
- Sections of sod should be a standard size (as determined by the supplier), uniform and untorn.
- Sections of sod should be strong enough to support their own weight and retain their size and shape when lifted by one end.
- Harvest, delivery, and installation of sod should take place within a period of 36 hours.

Sodding procedure

- Moistening sod after it is unrolled helps maintain viability. Store it in the shade during installation.
- Rake the soil surface to break the crust just before laying sod. During the summer, the sand should be wet on the surface before laying the sod to cool the sand and reduce root burning and dieback.
- Do not sod on gravel or soils that may have been recently treated with sterilants or herbicides.
- Lay the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger strips in a brick- like pattern. Be sure that the sod is not stretched or overlapped and that the joints are butted tightly to prevent voids. Use a knife or sharp spade to trim and fit irregularly shaped areas.
- As sodding of clearly defined areas is completed, roll sod to provide firm contact between roots and sand.
- After rolling, irrigate until the soil is wet 100 mm below sod.
- Keep sodded areas moist to a depth of 100 mm until the grass takes root. This can be determined by gently tugging on the sod – resistance indicates that rooting has occurred.
- Mowing should not be attempted until the sod is firmly rooted, usually 3-4 weeks.

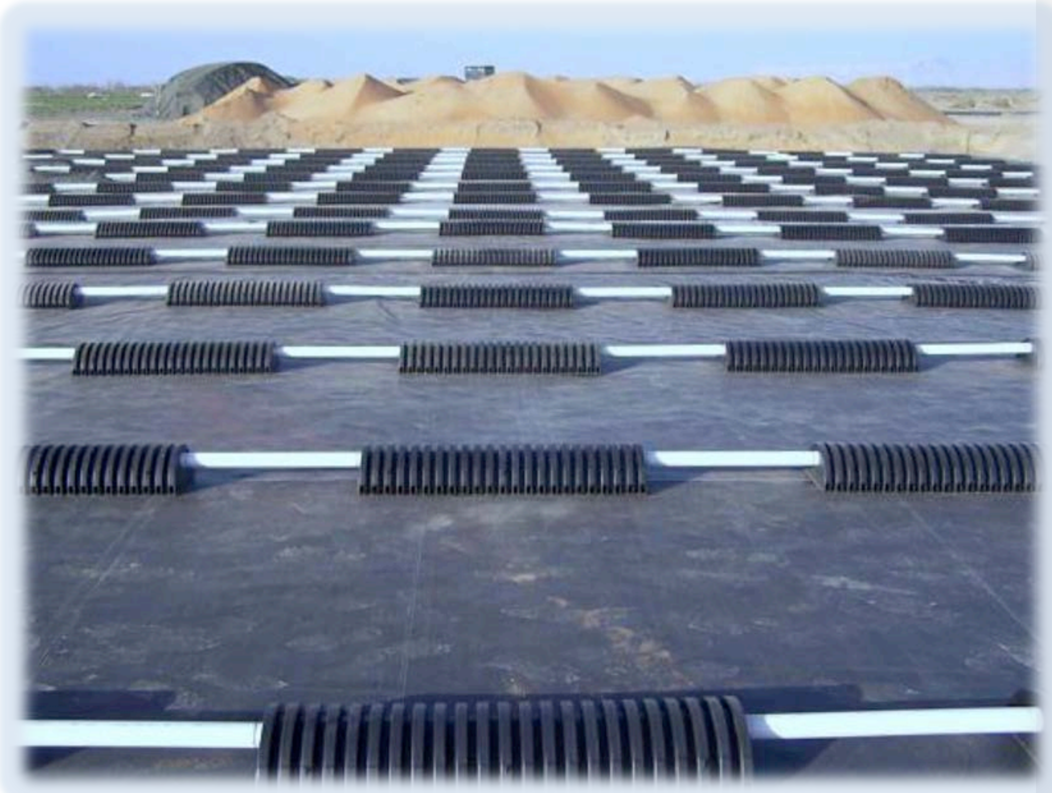
Flowers | Shrubs

- Recommend to dig out appropriate sand volume to receive root ball of nursery stock shrubs, perennials, and annuals
- Remove nursery shipping container, loosen root ball and discard any loose greenhouse planting media from plant. Do not damage existing root structure and only discard surrounding soil that falls off easily.

- Plant directly in sand and refill and press excavated sand around root ball of plant. Press down firmly around planting and smooth out sand surface after planting. Crown of plant shall be below the finished sand surface.

Trees

- Insert specified nutrient spikes around tree and pushed in to be 15cm below sand surface. Recommend watering 20 Liters around fill area of tree trunk for additional settling of sand fill, add additional sand to finish grade to balance settling.



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CLOSING SUMMARY

It is not within the scope of this manual neither to provide a definite identification guide nor to provide the solutions to all the problems. The subject is too complex with twists and variations that can at times even confound the "best" experts.

Some general "words of wisdom" to turf grass managers are offered below:

1. Don't take it as necessarily a failure of management practices. While no management or poor management programs can initiate stressed grass conditions, problems will occur at times even in the best managed programs. A lush green, vast area of sports turf may be the ultimate goal, but to nature it merely becomes an attractive smorgasbord of "food" for various opportunistic pests.

2. While we cannot control weather conditions, be aware of weather conditions. Applying fertilizers just before a rain event may be beneficial; applying it when the grass is still wet may not be a good idea. Some Fungicides and Pesticides on the other hand may be washed away and be useless if applied just before a rain event.

3. Be flexible. A tight schedule of maintenance activities shows determination and order, but it should have the ability to be overridden by common sense. Do not mow the grass if the grass is still wet. Do not use or even walk on the field if the frost is still on the grass blades.

4. Don't jump to conclusions. Be systematic and analytical in analyzing problems. Stressed grass conditions, as mentioned, can have many culprits. Some insects and fungi are invisible to the naked eye, others are not. A lot of damage may be occurring underground before it shows at the surface. No one person knows everything all of the time. Rely and obtain second and third opinions. Just when you know everything, Mother Nature can throw you a surprise.

Be patient. In a world of instant gratification - grass response is a misfit. Even on the best of conditions it will still take 5 to 10 days for grass seed to germinate, several more weeks to "look" green and several months to be ready to stand up to abuse. It may take several days and up to a week for pesticides and herbicides to be effective, and then only if we have chosen the right formula.