within the community, Halton staff has continually been involved with community based outreach events throughout Halton Region. In continuing with water conservation based public education, Halton Region and Conservation Halton partnered to provide the inaugural Halton Children's Water Festival in September of 2006 at Kelso Conservation Area in Milton, Ontario. Throughout the three-day event, over 3,000 grades 3, 4 and 5 students from across Halton Region participated in 56 interactive Ontario curriculum based activity centres focused on the main festival themes of water conservation, water health and safety, water protection, water science and technology and water stewardship. With the high success of the inaugural event, planning of the second Halton Children's Water Festival is currently underway. The 2007 event planned for September 25, 26, and 27, 2007, will again be held at Kelso Conservation Area and feature over 50 interactive activity centres for grades 2, 3, 4 and 5 Halton Catholic District School Board and Halton District School Board students.

Implementing Bylaws

The third measure used for water efficiency is the *Halton Water Use Bylaw* (Bylaw 42-04). This bylaw distinguishes permitted usages of water, provides specification as to qualified personnel who may operate water system infrastructure, specification regarding the components of water system infrastructure, and outlines water usage violations and penalties under violation of the bylaw. In addition to the terms listed above, the *Halton Water Usage Bylaw* also provides the ability to implement water usage bans, restrictions and watering policies. With reference to this, Halton Region introduces the odd and even day watering policy each spring to limit excessive levels of irrigation as an industry best practice in water resource management and stewardship.

Further Initiatives

In continuing to employ water efficiency measures, Halton Region is currently working towards the introduction of numerous programs including a residential toilet rebate pilot program, an ICI pre-rinse spray valve replacement program, school based water and wastewater Ontario curriculum based outreach program, and a landscape assessment program to promote outdoor water efficiency through the use of drought tolerant and native plants in home landscaping.

Furthermore, Halton Region has currently started development of the *Halton Water Efficiency Master Plan* to provide a measurable, sustainable and achievable water efficiency strategy. The plan, upon endorsement by Halton Regional Council, will see the introduction of an enhanced water conservation based program strategy and the introduction of an overall water efficiency reduction goal to be achieved over the next decade.

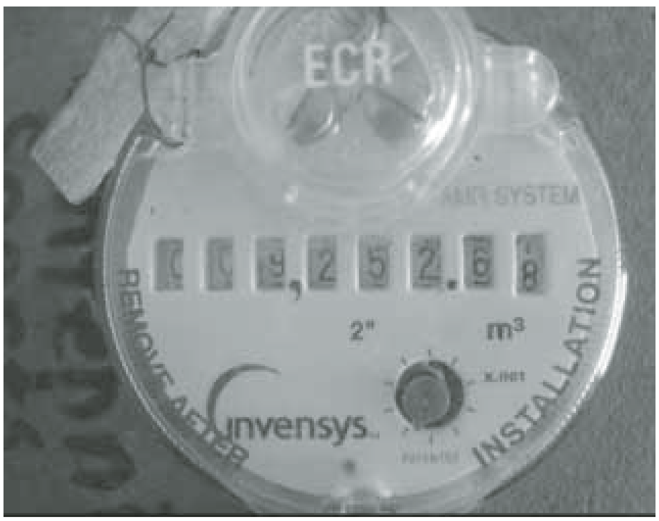
For more information on the *Halton Water Conservation Program*, please visit www.halton.ca/waterconservation. ♦

DEVELOPING AN IRRIGATION BASELINE

ARTICLE & PHOTOGRAPHS BY GREGORY SNAITH, P.ENG., ENVIROIRRIGATION™ ENGINEERING INC.

Using Water to Ensure Safety

A critical water use balance is essential to maintain a healthy, safe and functional turf sports field. Under irrigating a sports field may result in a playing surface that becomes dry, compacted and less safe for athletes. Sports turf managers require historical water use baselines which provide a datum to measure from while implementing higher water management technologies.



Daily Peak Demands

During the summer months, many cities and towns across North America experience daily peak demands which approach the rated capacity of water distribution infrastructure. In critical situations, this limits available water resources for emergency response and fire protection. While outdoor water use bans and restriction programs are created to decrease daily peak demands, these water programs are often in conflict with the required water to ensure athlete safety, functional turf sustainability and Integrated Pest Management program support.

Implementing the Water Efficiency Plan

An effective *Water Efficiency Plan* should separate the *Water Efficiency Program for Sports Fields* from the *Outdoor Landscape Water Use Program*. It only makes sense, since one is to provide a safe sports environment for the public while the other functions to achieve beautification. Since irrigation is generally considered a high water use sector, golf course superintendents and sports field managers should have strategic influence on the development of water efficiency plans. The double win opportunity would be a partnership between the city and the water purveyor (often the region) to promote water saving incentives including irrigation system performance auditing, training, technology upgrades and water use monitoring. For most cities, if water efficiency programs are not implemented, they will require major infrastructure expansion to accommodate future population growth.

Justifying Water Usage

Justifying water use for irrigation is based on the area of playing surface multiplied by the depth of water required. To implement water efficiency, it is essential every sports turf manager understands:

- soil water holding capacity
- drainage
- infiltration rates
- compaction
- evapotranspiration rates

A recommended resource on these topics is *Understanding Turf Management* written by Dr. Robert Sheard and published by the Sports Turf Association.

Typical Irrigation Baseline vs. ET Management

The majority of existing irrigation controllers rely on a weekly schedule of irrigation cycles that remain fixed until the sports turf manager adjusts them. Self adjusting water efficient irrigation controllers take into account both on-site rainfall and changing weather. Case studies have shown such automatic adjustments can account for seasonal water savings up to 30% or higher. Irrigation is only required to make up for the lack of timely and effective rainfall. For example, an effective rainfall of 10 mm on a 6,000 m^2 soccer field is worth \$120 if during a dry period the same amount was added by irrigation and the water cost was \$2 per m^3.

Record Keeping is Essential

Measurement of the irrigation system's performance whether a golf course, sports field or a commercial site, is the critical step in identifying baseline water use. Personal auditing experience proves that no one can judge with accuracy the efficiency of any system until it is measured professionally.

Verify Water Usage With Dedicated Flow Meters

Dedicated water meters are excellent water usage management tools and take the estimation out of volume calculations. The strategic key to implementing any water efficiency plan is to first establish and provide the historical water use baseline. This can be done by monitoring a dedicated water meter on a monthly basis and by providing a performance audit to the existing system.

Historical Water Use Baseline (HWUB)

The HWUB for any irrigation system is affected by:

1. Original irrigation design (ideally done by Certified Irrigation Designer independent from the sale or installation of any product).
2. Original irrigation installation (ideally installed by a Certified Irrigation Contractor with same project experience and inspected by a certified designer).
3. Maintenance of system (routinely checked and repaired).

4. Management of system (ideally by implementing monitoring and seasonal changes using Smart Water Application Technologies).

Once a water use baseline has been established it can then be utilized as a datum against the following:

1. Measure baseline against seasonal ET requirements (usually measured in mm per day, week or month).
2. Measure baseline against expected water efficiency technology performance (it is realistic to expect a rotor zone to operate at an overall efficiency of 75%).
3. Measure baseline against goals and/or objectives of a *Water Efficiency Plan* (the goal may be to decrease the water use by a realistic 20-30%).

The Irrigation Association, consultant, manufacturer, contractor and the distributor are all key team members playing their appropriate roles in providing technical and educational support for all irrigation systems. No matter how simple or complicated an irrigation system is, one thing is for certain, it is very difficult to measure improved water efficiency practices without first establishing the water use baseline. Remember, you cannot effectively manage that which has not been effectively measured. ♦

USE IT OR LOSE IT: BMPs FOR WATER MANAGEMENT

PAM CHARBONNEAU, TURFGRASS SPECIALIST, OMAFRA

Use it wisely or lose it should be the real slogan here. The goal is to provide turf with the right amount of water when it is needed and at the lowest cost and the least impact on the environment. There are negative consequences when turf receives too little or too much water. Not enough water can result in drought stress, thinning, localized dry spots and dormancy. Too much water, on the other hand, can result in shallow root growth, increased soil compaction, susceptibility to disease, leaching of nutrients, wet wilt and a waste of water due to runoff or drainage.

Turf & Water Interactions

A turfgrass plant is composed of 90% water. Water is also needed in every stage of plant growth. If water levels within a plant get below a critical level the plant will die. As little as a 10% reduction in turf water content may be sufficient to cause death. Water is needed for photosynthesis, cell division, temperature control and nutrient movement. The equation for photosynthesis showing the role of water (H_20) is below:

$$6CO_2 + 6H_20 \xrightarrow{\text{light}} C_6H_{12}O_6 + 60_2$$

Photosynthesis and cell division account for 1% of a plant's water needs. The majority of a plant's water needs are for temperature control and nutrient movement and these account for 99% of a plant's water need. All nutrients are moved into plants through the soil solution. This nutrient rich solution is taken up by the roots and transported via the xylem in solution. This movement occurs from the roots to all parts of the plant.

IMPORTANT
TABLES/FIGURES AVAILABLE
★ as an insert ★

Cooling of turfgrass plants is made possible because of water loss from the plant through transpiration (as a vapour). Ninety percent of the water loss is through the stomates. In a turf system, water is also lost from the soil through evaporation. There is a combined loss of water from the soil by evaporation and by the plant through transpiration and this is called evapotranspiration (ET). ET is difficult to measure, but it can be estimated. It is influenced by sunlight, soil and air temperature, relative humidity, wind speed, turfgrass species, height of cut of turf and rainfall. It is measured in inches/day, inches/week or mm/day. Evapotranspiration is used to calculate plant water requirements. It is estimated with a device called an evaporation pan. This gives the amount of water that evaporates from a flat shiny surface. It must then be adjusted for each crop and for each microclimate. One equation that is used to estimate plant water requirements is below:

$$PRW = ET \times K_c \times K_{mc}$$

PRW = plant water requirement
ET = evapotranspiration
K_c = crop coefficient
K_{mc} is the microclimate factor

Crop coefficients vary with each type of grass species and the height at which they are maintained. Most crop coefficients are based on seasonal averages. Some cool season turfgrass crop coefficients are listed in Table 1 (see insert).

Microclimates may also vary from area to area and for the purpose of this article, from sports field to sports field. The microclimate factor is a correction factor that relates to things such as proximity to buildings, paved surfaces, slope, shade and wind. A microclimate factor in a full sun sports field with heat reflecting and heat generating buildings nearby that is exposed to the prevailing winds would have a high K_{mc} and a microclimate with shade and no wind would have a low K_{mc} . In general there are three K_{mc} microclimate correction factors: high = 1.4, medium = 1 and low = 0.5.

An Alternative Method of Estimating Evapotranspiration

Some work done at the Cambridge Research Station by Dr. Robert Sheard came up with a way to estimate pan evapotranspiration based on observed weather conditions. This is an alternative method to having your own evaporation pan, which is easier, but may be a bit less accurate. Table 2 gives the estimated pan ET in millimeters based on weather observations at 1:00 pm.

A combination of the visual estimates of humidity and wind in addition to an observed temperature gives the estimate of pan evaporation. This then needs to be corrected for grass with the season correction factors found in Table 3.

ET calculation example:
Date – July
Sun – Sunny
Temperature – 27ºC
Humidity – low
Wind – low
Estimated pan evaporation from Table 2 (7.5) x seasonal correction factor from Table 3 (.75) = estimate of grass ET (5.5 mm) for that day.

Soil and Water Interactions

The amount of water a plant needs is influenced by soil particle size, soil particle size distribution (soil classification) and root zone depth. Soils can be classified according to their particle size into sand, silt and clay. Sands can be further divided into five categories: very fine sand, fine sand, medium sand, coarse sand and very coarse sand. Table 4 shows the particle size diameter of coarse sand down to silt and clay.

For every field that you are responsible for irrigating within your municipality, it is very important to know the soil classification or particle size distribution of that field. Without this information, it is almost impossible to accurately deliver the right amount of irrigation. One way of obtaining this information is to have a soil laboratory run a soil texture analysis of every field. This is a useful exercise and only needs to be done once in the life of a sports field. A cheaper and quicker method is to simply use the mason jar test and a soil texture triangle. Just follow the steps below. Figure 1 shows a mason jar with roughly 80% sand and 20% silt.

1) Fill a mason jar 1/3 full of a random sample of soil from one field.
2) Pack it down and mark the level with a permanent marker.
3) Add water to fill the jar 3/4 full.
4) Shake vigorously.
5) Let sit for 5 minutes.
6) Measure the sand layer (the one on the bottom of the jar) as a percent of the depth of the original soil.
7) Measure the silt layer (the one above the sand layer) as a percent of the depth of the original soil.
8) Add the percent sand and percent silt together and subtract that from 100 to get percent clay (the clay is still suspended in the water).

Figure 1: Mason Jar Test

Now that you know that you have an 80% sand and 20% silt soil you can go to the soil texture triangle (Figure 2) to determine the soil classification. Follow the percent sand arrow over to 80 and follow the % silt down to 20 and follow each of those lines to the point where they intersect. In our example, we end up in the loamy sand area of the triangle. Soil texture affects plant available water and water infiltration rates. Both of these are important factors in determining efficient irrigation scheduling.

Infiltration rate is a measure of how quickly water enters soil. It is greatest at the beginning of an irrigation event or rainfall event and again it is influenced by soil texture. Infiltration rates of each soil or each field can be measured in one of two ways. A double ring infiltrometer is the most accurate way of measuring infiltration rates. Another way is to simply put on the irrigation system and measure the time until runoff. Infiltration rates can also be estimated if you know the soil texture. Table 5 gives a list of the basic infiltration rates of six different soil classifications.

Another important aspect of a soil is its available water. This is the amount of water stored in a soil between field capacity and permanent wilt. Another way to think of it is the amount of water that the plant can extract from the soil. In fine textured soils such as a clay loam, some of the water is held so tightly onto the soil particles that it is not available to the plant. In a coarse textured soil, some of the water applied to a soil is not available to a plant because it is lost through drainage. Table 6 gives the available water in mm based on soil texture. If you are using the calculation based on soil texture, the plant available water is the available water multiplied by the active root zone depth. There are two instruments that can be used in the field to measure plant available water: a time domain reflectometry probe (TDR probe) and a frequency domain reflectometry probe (Theta probe). Both of these methods measure volumetric water content.

Plant available water is the available water which can be measured in the field or it can be calculated based on soil texture. To calculate plant available water:

Plant available water = available water (from Table 6) x root zone depth

Example:
Sandy loam soil with a 300 mm root zone
Plant Available Water (PAW) = (available water from Table 6) 0.12 mm water/mm soil x (soil root zone depth) 300 mm soil
PAW = 36 mm water

Another important concept in the field of irrigation is how much water can be depleted from a soil before there are adverse affects to the plant. This is called the maximum allowable depletion. In general, it is agreed upon that if plant available water is allowed to deplete to 50% before re-applying water that there will be no harmful effects on the turfgrass plant.

Below is an example to help put all of the pieces together. Table 7 shows an example of a water budget. The assumptions in the example are:

- A sandy loam root zone
- Rooting depth 300 m
- Plant available water is 300 mm x 0.12 mm/mm = 36 mm
- Want to irrigate when 50% of available moisture is depleted (ie. at 18 mm)
- Assume field capacity on day 1 = 36 mm plant available water

This example shows that this particular field, when ET rates are high, the field needs only to be irrigated every second or third day.

Sprinkler Performance

Now that the plant side is taken care of, let us look at irrigation system performance. In order to irrigate efficiently, you must have an irrigation system that is performing properly. Irrigation system performance can be determined by an irrigation audit. This can be done in-house or you can hire an irrigation auditor to perform it. An irrigation audit will ensure that all sprinkler heads are level and that the pressure is relatively uniform. It will also determine the distribution uniformity (DU) of the irrigation system and this is calculated by measuring catch device volumes in the field. An irrigation audit will also determine the precipitation rate (PR). This is the rate at which water is applied per unit time (in/hour or mm/hour) and it is often referred to as the application rate. With this information you can determine your run time multiplier and finally your maximum run time cycle.

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Irrigation Scheduling

The next question should be "How long do I have to run my irrigation system to deliver 14 mm or 24 mm of irrigation?". If you have performed an irrigation audit, you can easily determine your run time. To determine this you need to know the following:

- run time multiplier (RTM)
- distribution uniformity of the lower quarter (DU) (from irrigation audit)
- precipitation rate (PR) (from irrigation audit)
- base run time(RT_b) RT_b = plant water requirement/precipitation rate x 60.

With the above information you can then:
- calculate the adjusted run time (RT_{adj}). $RT_{adj} = RT_b$ x RTM
- calculate the maximum run time/cycle = infiltration rate/precipitation rate x 60

The run time multiplier is a correction factor that is used to compensate for non-uniformity of distribution of an irrigation system. Run time multipliers can be found in the Certified Golf Irrigation Auditor workbook put out by the Irrigation Association and they can also be found on the internet. The infiltration rate can either be estimated based on soil texture or you can determine it with a double ring infiltrometer as discussed earlier in the article.

Example run time calculations based on the water budget example above:
- Base run time RT_b = PWR/PR (24 mm/ 15 mm (from irrigation audit) x 60) = 96 minutes
- Adjusted run time RT_b x RTM (96 x 1.22 = 117 minutes)
- Infiltration rate – 14 mm (from Table 5)
- Maximum run time/cycle
- Infiltration rate/precipitation rate x 60 = 14 mm per hr/15 mm x 60 = 56 minutes
- The maximum time this zone should be run to avoid runoff is 56 minutes. Basically, two run cycles of roughly 56 minutes will deliver the required amount of water to recharge the root zone in this water budget example.

Irrigation Checklist

This checklist below gives a quick overview of the information and/or equipment needed to be able to apply the right amount of water to turf.

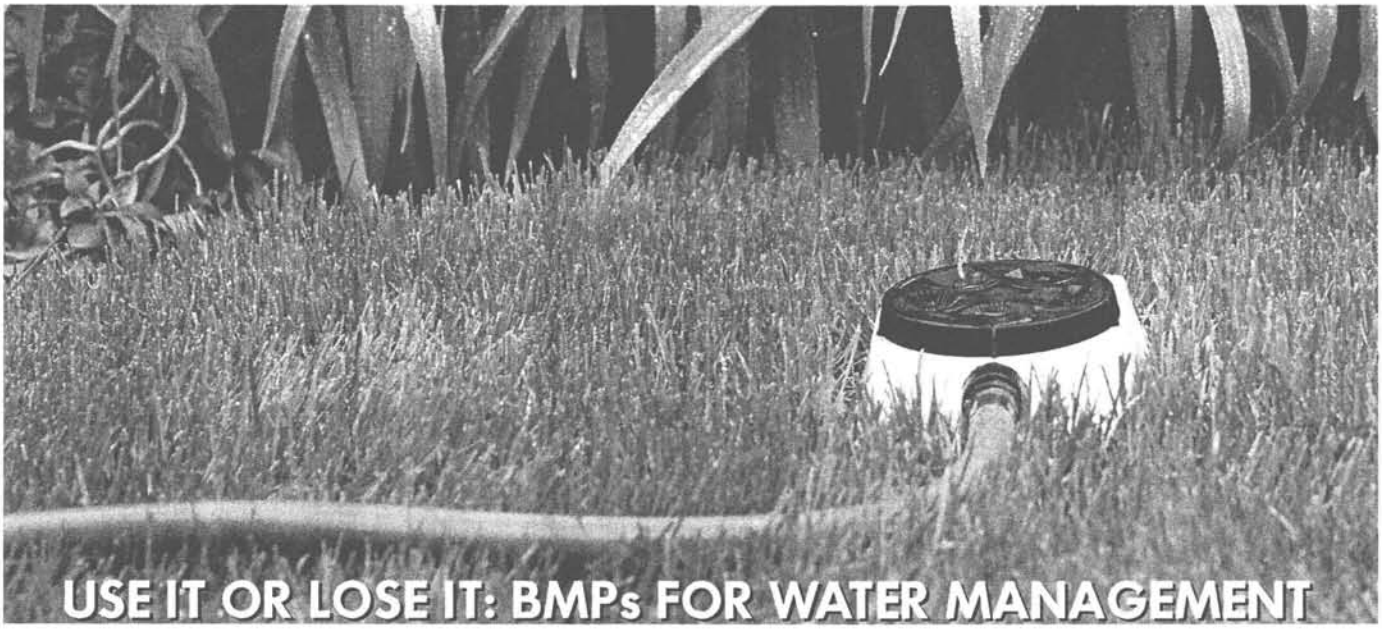
1) Determine soil texture of each irrigated field (mason jar or lab).
2) Make note of the infiltration rate (based on soil texture, double ring infiltrometer or observation of time to runoff) and available water (based on soil texture) and root zone depth for each field.
3) Calculate plant available water = available water x root zone depth.
4) Perform an irrigation audit to determine precipitation rate and distribution uniformity.
5) Keep track of ET rates based on temperature, humidity and wind.
6) Have a method for measuring rainfall and a rain shut off feature.
7) Use the water budget to schedule irrigation.
8) Use run time calculations to determine how long to water.
9) Schedule to water only in early morning (low wind and less evaporation).
10) Ground truth by inspecting fields to make sure the turf is getting adequate water and that there are no over-watered, under-watered areas or localized dry spots.
11) Have a dedicated knowledgeable staff person in charge of irrigation.
12) Don't forget other cultural practices for maintaining healthy turf:
- Mow as high as possible and frequently enough to maintain a stress-free plant.
- Alleviate compaction (core aeration, etc.) which helps maximize infiltration rate.
- Control thatch.
- Fertilize according to the plant's needs.

Abbreviations

DU =	disribution uniformity
ET =	evapotranspiration
K_c =	crop coefficient
K_{mc} =	microclimate factor
PAW =	plant available water
PR =	precipitation rate
PWR =	plant water requirements
RTM =	run time multiplier
RT_{adj} =	adjusted run time
RT_b =	base run time

References

1) Carey, K. C., 2001. Irrigation Scheduling Principles: Tools for Dry Times. *Sports Turf Newsletter*, Vol. 14, pp. 6-7.
2) Irrigation Association, 2004. *Certified Golf Irrigation Auditor*, pp. 65-82.
3) Sheard, R.W., 1992. A Water Budget for Irrigation Scheduling. *Sports Turf Newsletter*, Vol. 5, pp. 5-7. ♦



USE IT OR LOSE IT: BMPs FOR WATER MANAGEMENT

Table 1. Crop coefficient examples.

Grass Classifications	Mowing Height	K_c
Cool season	10-15 cm	1.0
Cool season	8.0 cm	0.95
Cool season	5.0 cm	0.90
Cool season	3.0 cm	0.85
Cool season	2.5 cm	0.80

Table 2: Estimators for pan evaporation based on observed weather conditions.

	One pm weather observations for:			Estimated Pan Evaporation (mm)
Sunshine	Temperature (C)	Humidity *	Wind**	
Full	Greater than 23	Low	High	8.0
Full	Greater than 23	Low	Low	7.5
Full	Greater than 23	High	High	7.0
Full	Greater than 23	High	Low	6.5
Full	Less than 23	Low	High	6.5
Full	Less than 23	Low	Low	6.0
Full	Less than 23	High	High	5.5
Full	Less than 23	High	Low	5.0
Cloudy	Greater than 23	Low	High	5.0
Cloudy	Greater than 23	Low	Low	4.5
Cloudy	Greater than 23	High	High	4.0
Cloudy	Greater than 23	High	Low	3.5
Cloudy	Less than 23	Low	High	3.5
Cloudy	Less than 23	Low	Low	3.0
Cloudy	Less than 23	High	High	2.5
Cloudy	Less than 23	High	Low	2.0

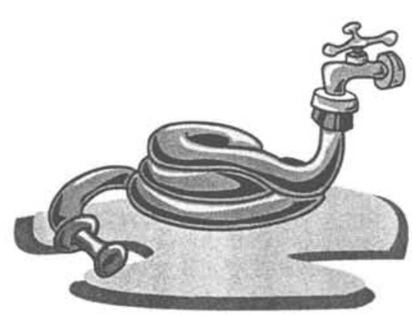
* Low = clear sky, unlimited visibility; High = smog, haze, fog
** Low = leaves and small branches moving; High = tree tops moving

Table 3. Seasonal correction factor for adjusting pan evaporation to grass ET.

Month	Correction Factor
April	0.45
May	0.55
June	0.65
July	0.75
August	0.75
September	0.55
October	0.45

Table 4. Soil particle diameter of very coarse sand to clay.

Soil Particle	Size range (diameter in mm)
very coarse sand	1.0-2.0
coarse sand	0.5-1.0
medium sand	0.25-0.50
fine sand	0.10-0.25
very fine sand	0.05-0.10
silt	0.002-0.05
clay	<0.002



ACCOMPANYING TABLES & FIGURES FOR PAM CHARBONNEAU'S ARTICLE, PP. 24-26.