lection. They must be chosen on the basis of *efficient performance* which will result in production of high quality turf, shrubs, trees, and flowers, with a minimum use of water.

Conservation of water is a vital issue in many areas and will inevitably become so in all areas. Among the first requirements for a small area irrigation system, then, must be application of water in a manner which results in maximum conservation. This can occur only when a watering system has flexibility to: (1) apply water in a manner suitable to a wide range of plant and soil conditions; (2) provide for maintenance of good soil-air-water relationships; and (3) permit application of water in "off-peak" use periods.

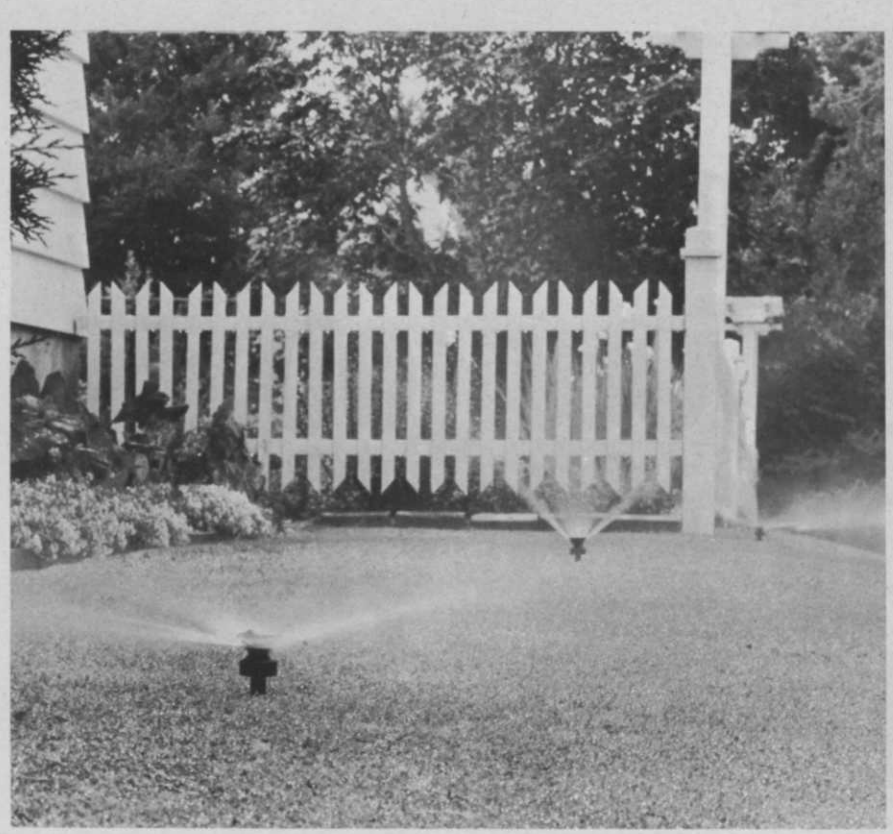
Amount of Water:

The amount of supplemental water required to keep lawns green and healthy throughout the growing season is dependent, principally, on temperature, sunlight, wind movement, and rainfall. For example, in the midwest, to sustain growth and to keep turfgrass green during the growing season, it has been calculated that supplemental water will have to be applied in varying amounts for 4 to 5 months, 65 to 75 percent of the growing season. This calculation is based on average weather data for the climatic regions for the midwest over a 30-year period.

Methods of Applying Water:

Techniques for applying water to small areas are flooding, sub-surface watering, and sprinkling. Flooding and subsurface irrigation are the least efficient from the standpoint of water distribution and use. These methods are seldom, if ever, used.

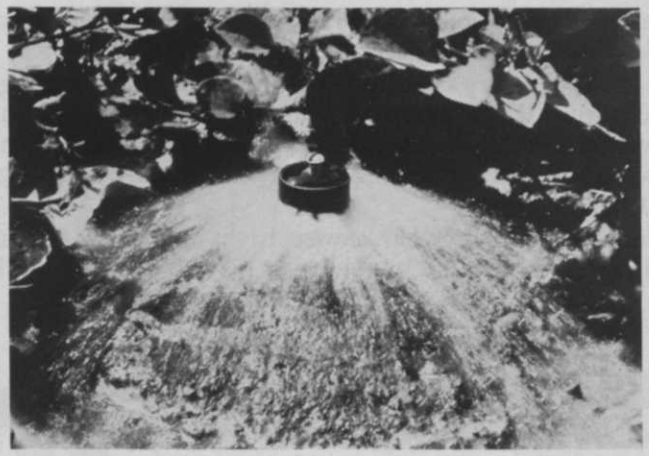
Hose-end devices, overhead (solid and portable), and underground sprinkler systems are the usual means of watering small areas. Of these, hose-end devices are, by far, the most generally used, especially on home lawns. Some hose-end sprinkling is done on larger areas, but most facilities such as athletic fields, industrial lawns, and small parks are watered by some type of underground system. Overhead systems are used for nurseries, sod farms and similar areas where a "crop" is involved and conventional cultivation is necessary. This type plays a minor role in the irrigation of small areas.



This pop-up sprinkler is excellent for watering small, complex areas.

Hose-end Sprinklers:

Hose-end sprinklers are available in many sizes, types, and prices. Such sprinklers often deliver water at rates faster than the soil can accept or absorb it, many times at a cloud-burst intensity of one inch or more per hour. Under such conditions, they need to be moved frequently. And, since this must be done by hand, there is a tendency to overwater and to waste water in runoff or in excessive percolation on well drained soils (movement of water through the soil profile). Also, little distinction is made between shady and sunny, or high and low areas. In addition to the inefficiency and inconvenience asso-



Bubbler sprinklers allow roots to be watered without wetting the plants' leaves.

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This pop-up sprinkler is directing water away from the leaves.

ciated with many hose-end sprinklers, labor costs (or time on the part of the worker or homeowner) are greater and the devices must be used, generally, during peak-use periods.

Underground Sprinkler Systems:

These are pre-planned for complete coverage of an area. When properly designed, installed, operated, and serviced, they are the most efficient way to irrigate. Underground systems may be of the quick-coupling or of the fixed-head type. They may be operated manually or by a pre-set clock similar to a clock-radio or an oven. (When quick-coupling systems are actuated and turned off—controlled—with a controller, they are called "semi-automatic").

If reliable, well trained manpower is available, the job of applying water to small areas can be accomplished with a quick-coupling or a clock-controlled automatic system, or even with a hose-end sprinkler. However, since such operators are rarely available, there is little doubt that the most effective, efficient, convenient, and economical way to water both small areas and large areas is by automatic underground sprinklers. Clock-controlled systems are flexible and constant. They are always on duty and available on demand. They prevent waste.

Automatic Systems:

There has been marked progress in the development of equipment to permit automatic watering of turfgrass and other landscaped areas within the past few years. Equipment presently available permits the controlled application of precise amounts of water. Further, such systems are capable of delivering the water in accordance with the needs of grass, trees, shrubs and flowers in conformance with the ability of a given soil to take it (infiltration capacity) and to store it (watering-holding capacity). Most important, systems today are economical and assure conservation of water with minimal operating cost.

Numerous advances in controllers, valves, and sprinklers have occurred within the past few years. Thus it is well to keep in mind that any system, old or new, irrespective of how well it has been installed, used, and maintained can be no better than its basic design.

Design:

Good system design and hence good performance have to start with the specifications laid down by the owner or his representative, preferably, someone with knowledge of turfgrass requirements. He must specify what he wants the system to do.

Basically, any system design is a compromise between cost and performance. Thus, the owner (or operator, or turfgrass manager) must make certain basic decisions, all of which revolve around obtaining the best performance for the costs involved.

Design of a system starts with the owner, operator, or turfgrass manager answering such questions as: area to be covered, hours available for watering, amount of water to be applied, type of system, precipitation rate, wind velocity, and service life of the equipment. Answers to these questions, once incorporated into the system design, are fixed.

The area to be covered or watered must be determined, preferably by use of an accurate plot plan. There will be no embarrassing questions later if this is scaled and laid out in advance.

On large areas like golf courses and parks, when the time available or allowable to apply a specified amount of water is limited or restricted, the cost will be substantially affected. This may also be a factor on small areas and is one reason that a competent irrigation specialist should be con-

A shrub sprinkler irrigates this vegetable garden.

sulted on system design for small as well as large areas.

A system is purchased to water grass and to keep it green during the growing season. This often coincides with the driest time of the year. Failure to specify a system large enough to provide adequate water will produce trouble for all concerned.

Wind Condition:

The importance of wind is often over-looked. Performance of various pop-up heads varies only slightly. So, a standard spacing chart may be of use as a guide.

Standard Spacing Chart for Pop-up Heads

Wind Velocity Miles Per Hour	Maximum Triangular Spacing (Percent of Diameter)
0- 3	70
3- 5	60
5- 7	50
7-10	40

The number of heads required for effective watering goes up in inverse proportion to the square of spacing. Therefore, 3 times as many heads would be required in an 8 to 10 mile-per-hour wind as are required in a 0 to 3 mph wind. Substantial savings may be affected by scheduling watering periods to coincide with time periods when wind is low.

These factors plus information on the maximum precipitation rate allowable and uniformity of precipitation and service life (durability) of the various component parts are critical to proper design. They must be specified by the owner or his representative.

Once these decisions are made and turned over to a sprinkler system designer, a system to meet your specifications may be designed. Do not fall into the trap of ignoring such specifications; or of relying on some well-meaning friend who tells you that you should use only X pipes, Y heads, and Z controls and valves. They may be perfectly good but not compatible with the needs of your turfgrass area. Failure to specify the basic requirements for a given system has resulted in unsatisfactory performance of many systems, both automatic and manual. One further advantage of specifying is that responsibility for performance is easily assigned to the designer. Specify the area, the hours, the amount of water, type of system, maximum wind and precipitation, and service life.

Summary:

To use water properly requires an understanding of the fundamental role water plays in plant growth; of the effects climate and weather have on growth rates; how they influence water-use rates and choice of grass or plant materials. Good watering practices demand a knowledge of the basic physical and chemical soil properties, how they affect water absorption, storage and drainage as well as the frequency, rate and manner in which water must be applied.

Small area irrigation requirements are similar in principle to those of large areas. They have the same basic function but may need to be more precise because of the complexity of landscape. The role of small area irrigation is important because of the impact that small areas, in total, have on the aesthetic and economic life of a community.

Small area irrigation systems must perform efficiently and effectively. They must permit maximum conservation of water and they should be economical to operate. They should be designed by a specialist, installed properly, and serviced routinely.

Clock-controlled (automatic) underground sprinkler systems provide the best answer to the problems associated with irrigation of small areas. Their flexibility permits correct watering despite the varied conditions that exist on small areas. Also, they are economical to operate and they conserve water.

Clarke Outdoor Spraying Company, La Grange, Ill., is using a helicopter for golf course and tree spraying in the Chicago area. Clarke has found the demand for this type custom spraying good from February until freezing weather in the latter part of the year. Pilot for Clarke is Charles J. DuPont, a veteran pilot of some 20 years.

For Contract Applicators

Helicopter Is Versatile Tool

GOLF COURSES in metropolitan Chicago are becoming regular clients of Clarke Outdoor Spraying Company. With their helicopter, Clarke can spray the fairways on an 18-hole course in 1½ hours. Custom spray rates for the job are reasonable, especially when the savings in time on a revenue producing course are considered.

Charles J. DuPont, aviation manager and pilot for Clarke, says they have now established standard prices. Clarke was among the first, if not the first contract applicator, to spray golf courses on a commercial basis. Their price for spraying 18 fairways, is $100, and the same is true for greens. Cost of dry granular application is based on pounds applied per acre. These rates range from 65¢ to $2.35 per acre.

Helicopter application costs, according to DuPont, appear somewhat higher than the cost of using ground spray equipment. In the Chicago area, DuPont says, use of ground spray equipment will range between $60 and $70 for 18 fairways or a comparable number of greens. But this cost, he says, does not include the time of the superintendent, or other hidden costs such as down time for the course. Even though many courses are

Clarke uses Hughes 200 helicopter with fully articulated rotor. This model is small and compact and lends itself to close-in spray work. Pilot DuPont says that he normally flies about 5 feet above golf greens and fairways when spraying. Advantages of helicopter include labor saving, speed, and ability to spray when ground is soft.

Aerodynamic characteristics of the helicopter's rotor system creates what is referred to as "blade tip vortices." Because of the extreme turbulent air created, vortices are normally considered an undesirable area in which to introduce spray. Experience of pilot along with spray equipment thus become very important in even coverage. DuPont depends on vortex action to increase coverage in hard-to-cover tree tops and crotches.

closed on Mondays, superintendents find it difficult to spray both fairways and greens along with their regular maintenance in a single day.

Helicopter Saves Labor

Besides time, the key plus factors for the helicopter involve the climate and labor supply. Helicopters can spray when ground is too soft for ground equipment. Also, they do not tie up course help, except for fertilizer applications. In the latter case, 2 men are supplied by the course for help in loading. Another advantage of the helicopter is that which is so important in rights-of-way maintenance. It can easily cover inaccessible areas.

Clarke's spraying business includes larviciding, fogging, misting, inspection, and regular spraying. John Clarke, manager, purchased the helicopter primarily for use for mosquito spraying on areas impossible to reach with ground equipment. Spraying trees for control of Dutch elm disease followed. Since much of the tree work involved golf courses, spraying of fairways and greens was the next logical step. DuPont reports that Clarke last year gave several demonstrations for superintendents, a number of whom are now clients.

The helicopter can do a good job of spraying trees. Down wash from the rotor produces good coverage in the new growth areas of tree tops. Crotches are also well covered. Difficulty is in spraying trees along streets because of traffic and parked cars. DuPont says this is difficult but can be done with close cooperation of police and park departments. Where the trees are accessible, such as in parks or on golf courses, DuPont can cover 334 trees per actual hour of flying time.

DuPont points out, however, that ferrying time must be allotted in scheduling time between jobs and the normal wait for the service or nurse truck cuts down the number of spray hours per day. Clarke finds that 4½ hours spray time is normal on a good day. Scheduling is based on average weather conditions. John Clarke and DuPont checked meteorological data for the Chicago area for the three years prior to the '68 spraying season. Temperature, wind, and moisture were plotted. They then charted the expected average weather picture for this season as a base for setting up weekly work schedules. The helicopter cannot be used for spraying if wind is more than 15 knots (approximately 17¼ mph). For Dutch elm disease control on trees, the limit is 10 knots.

Season Begins in February

Spraying season for Clarke's helicopter business normally begins in late February. September through late October is almost dead time. Business then increases from late October until winter weather intervenes. Last season, DuPont reports that Clarke was able to spray until December 13.

Clarke's helicopter is a Hughes 200 with fully articulated rotor (3 blades). The 3-bladed rotor system is smoothest and most responsive in flight. This model is small and compact and a very practical type for spray work according to DuPont, a veteran pilot with 20 years of helicopter flying experience.

Operating cost including gas, oil, scheduled and unscheduled maintenance, and reserve for limited life item replacement amounts to about $22 per hour of flying time. A Hughes spray system is also used. This is a 36-foot boom equipped with 37 nozzles.

Such a unit has a broad application in the field of custom application. Fungiciding of fairways and greens had been well established. Cadminate, chlordane and ferrous sulphate were used in one application, DuPont reports. In another, actidione R. Z. was used in a standard mixture of 40 gallons of water per acre. Later, a reduced water mixture was also used with good results, important because it proved that the fungicide can be used safely with less than the normal quantity of water.

Fly control has proved to be very practical. Dibrom 14

used with a sugar water carrier has given successful abatement of adult flies for 1 week. Solution has been applied at rates of ½ gallon of water, ¼ pound of sugar, and 3 ounces of dibrom per acre. For shorter range kills, ultra-low volume applications of 1½ ounces per acre have been used successfully.

DuPont points out that not only may trees be sprayed for insect and disease control, but foliar applications of fertilizer are practical. Results to date have been excellent in controlling the elm bark beetle. Great advantage in this area is that a large volume of work can be done in a minimum of time.

Legal problems of using helicopters in metropolitan areas will vary. Federal regulations generally apply only if a helicopter is carrying passengers. Custom spray helicopters do not carry passengers, nor do they fly over congested areas since golf courses are generally in the open. Civil complaints because of noise, may arise. But DuPont believes these can be handled by education in the form of publicity. Club members who know the program can be a help.

Noise levels of helicopters can be expected to drop considerably during the next few years. Coming of the jet-turbine engine will help. Also, tail rotors such as the new model designed by Hughes which operates at a much reduced r.p.m. will help. Further advances in dispersing equipment can be expected and will greatly aid the custom applicator using helicopters. DuPont believes the time will come when a spray unit will be developed which can sense airspeed and regulate the rate of spray output to provide a constant flow per acre. Improvements are also needed in swath control, he says. This can prevent excessive dosage and give the custom applicator better control, and generally aid the industry.

Meeting Dates

Keystone State Association of Cemeteries, Spring Convention, Shawnee on the Delaware, June 9-12.

Turfgrass Sprinkler Irrigation Conference, University of California Extension Conference Center, Lake Arrowhead, Calif., June 21-23.

Tri-County Chapter, California Landscape Contractors' Association, 17th Annual Convention, Ojai Valley Inn and Country Club, Ojai, Calif., June 25-29.

Landscape Seminar, Associated Landscape Contractors of America, Inc., for Michigan and Ohio, Dearborn Inn, Dearborn, Mich., July 13.

National Fertilizer Solutions Association, 1968 NFSA Round-Up, Regency Hyatt House, Atlanta, Ga., July 25-26.

Lawn and Utility Turf Growers Field Day, Rutgers University, College of Agriculture and Environmental Science Campus, New Brunswick, N. J., July 30.

Golf and Fine Turf Growers Field Day, Rutgers University, College of Agriculture and Environmental Science Campus, New Brunswick, N. J., July 31.

Midwestern Nurserymen's Summer Meeting, Zelenka Evergreen Nursery, Grand Haven, Mich., August 13-14.

1968 Turfgrass Field Day, Pennsylvania State University, Joseph Valentine Turfgrass Research Center, Campus, noon August 21-noon August 22.

Lawn and Ornamentals Days, Ohio Agricultural Research and Development Center, Wooster, Ohio, September 10-11.

1968 Southern California Equipment and Materials Educational Exposition, City Park, Lynwood, Calif., October 16-17.

American Society of Agronomy, 1968 Annual National Meeting, Jung and Roosevelt Hotels, New Orleans, La., Nov. 10-15.

Weed Science Society of America, Annual Meeting, Las Vegas, Nev., February 10-13.

Red Alert for Spraymen

(from page 9)

less calcium, or other elements in water samples.

The question among spraymen who deal with aquatic weed control is how to apply findings such as these. The answers, once water samples are analyzed are simple. For example, Dr. Toth reports that rainbow trout and other fish suffer from nickel and other heavy metals. Rainbow trout do not survive in water with more than 0.1 ppm of nickel. But at the same time, brook and brown trout can survive in water at this level of nickel content.

Dr. Toth reports that, based on atomic absorption analysis of water, his research group can accurately predict what water can be stocked with certain fish in order to assure maximum productivity and eliminate fish kill. For the spraymen who treats water for weed control before a restocking program, such information based on water analysis may prevent many later problems.

Sterile Lakes Are Problem

Further, Dr. Toth says, the damning of a stream to form a lake without checking the tributary water may lead to creation of a sterile impoundment. This is illustrated in the case of Matawan Lake at Matawan, N. J. Two tributaries to this lake contribute sufficient sulphuric acid and soluble aluminum to kill almost all of the animal and plant life. The pH of this lake has been as low as 2.8 with soluble aluminum content exceeding 25 to 30 ppm and with an iron content of 12 to 25 ppm. It is obvious that water of this type is unsuitable for recreational or industrial use.

Establishment of farm ponds in the New Jersey inner coastal plains area often leads to conditions similar to that in Matawan Lake. Use of water from such ponds for irrigation of lettuce, tomatoes, and peppers can lead to severe crop damage. Waters of this type, however, can be treated with superphosphate and lime to raise the pH and precipitate the heavy metals.

Dr. Toth reports that his group can analyze with atomic absorption and accurately predict what water can be used effectively for irrigation of crops and golf greens. Burning of golf greens after irrigation has been common in the past. Recently, Dr. Toth reports, he analyzed irrigation water used on a golf course which was suffering burned greens. Water being used was high in copper and acid, thus causing the burning. Analysis of the water before irrigation could have prevented this situation and others like it.

Establishment of farm ponds in the New Jersey coastal plains area of the Southern region also creates problems when these ponds are used for recreation. The low content of bases and other nutrients in water of this region requires that the waters be periodically limed and fertilized for fish production. Large natural or impounded lakes and ponds in this region cannot be treated economically in this manner and must be considered as having very low fish productivity ratings.

Attempts to modify the composition of stream waters in this area using limestone or basic slag beds have not been successful.

WTT is indebted to Dr. Stephen J. Toth, Department of Soils and Crops, Rutgers University, New Brunswick, N. J., for his assistance in the foregoing presentation. Dr. Toth reports that his laboratory can process water samples on a custom basis, at cost, if commercial laboratories are unable to do so. Work is performed by graduate students who receive the fee. Spraymen, irrigation contractors, golf course superintendents, and turf specialists may contact him directly at Rutgers.