Simulation of Putting Green Hydrology

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Objectives:

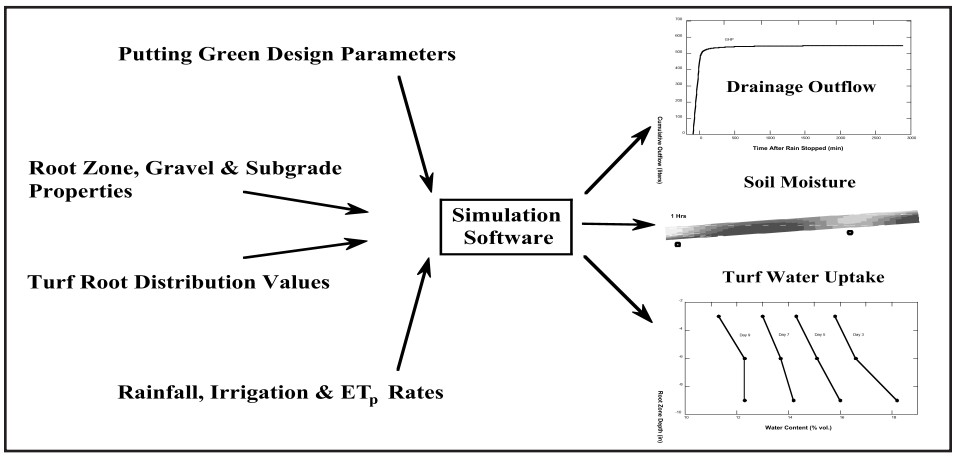
1. Identify the appropriate soil hydrology model capable of simulating existing data and extending the range of conditions corresponding to actual putting greens.
2. Validate and calibrate the model using existing data on water infiltration, redistribution, drainage and turf uptake under prescribed experimental conditions.
3. Use the model to generate simulations of putting green hydrology for a variety of realistic and interesting green construction and environmental scenarios.

Start Date: 2001
Project Duration: 2 years
Total Funding: $28,850

Putting green hydrology encompasses the dynamic processes of water infiltration, runoff, redistribution within the profile, drainage, and water uptake by the turf. We have gained some understanding of each of these hydrologic processes, however, this understanding is limited to a relatively small set of experimental conditions. A wider investigation may be realized through simulation of putting green hydrologic processes using a soil hydrologic model.

HYDRUS-2D is a hydrologic simulation model developed at the USDA-ARS Salinity Laboratory in Riverside, CA. This model can simulate water flow, the transport of multiple solutes and heat, in one- or two-dimensions for both saturated and unsaturated soils. The model can also handle flow regions delineated by irregular boundaries such as the natural contours of a putting surface. The flow region itself may be composed of vertically distinct layers, as would be the case for the soil profile in modern, high-sand-content greens. The model includes implementation of a free drainage boundary condition as would occur due to the placement of subsurface drains, and incorporates a time-dependent sink term to account for diurnal water uptake by turf. There is, in turn, a feedback mechanism for reduced evapotranspiration (ET) as soil moisture becomes limiting. Finally, the model allows time-varying inputs to the soil surface accurately representing rainfall or irrigation conditions.

The validation and calibration steps in Objective 2 are required to gain confidence in the model's ability to precisely describe



Researchers at The Ohio State University are using a hydrologic simulation model to estimate water movement in putting green rootzones.

putting green hydrology for scenarios that are not available from experimental findings. Agreement between the model output and the experimental data would indicate the suitability of the model for describing water flow in greens.

Our initial model validation studies employed a 2-tier soil profile (12-inch rootzone over a 4-inch gravel layer) with rootzones ranging from unamended sand to a sand-topsoil-peat blend. Water retention and saturated hydraulic conductivity values used as model inputs were from measurements or literature estimates. Turf rooting for each rootzone was described using a negative logistic function that was fit to field measurements. Simulations were run from hour 3700 (day 154) to hour 5376 (day 224) of year 2001. Time-variable boundary conditions consisted of measured rain or irrigation amounts and daily turf ET estimates. ET estimates were calculated by multiplying measured pan ET by a crop coefficient value of 0.45. Finally, a critical soil water suction that limits root water uptake was estimated from the water retention curve and the smallest measured water content values.

Outputs from the model consisted of hourly values of soil water suction, water content, turf ET, and drainage depth. To date, some inconsistency between measured and simulated data is apparent. From field measurements, this value was estimated to be 10 cm of water, whereas the model simulation predicts a value of 2 cm. Even though this difference is slight, the simulation tends to over-estimate soil water contents and under-estimate drainage depths. Our current efforts are to rectify this observed inconsistency. On the other hand, measured and simulated turf ET is qualitatively similar.

Summary Points

- HYDRUS-2D, a hydrologic simulation model, has been selected for this research and appears suitable for describing water flow in the layered soil profiles that are used in putting greens.
- Preliminary analysis, however, has shown some inconsistency between measured and simulated findings. The source of this inconsistency appears to be a difference in equilibrium soil water suction at the interface between the rootzone and gravel layers.