SECTION V BASIC GROUND WATER HYDROLOGY
FOR
THE DESIGN OF SUBSURFACE WASTEWATER ABSORPTION SYSTEMS

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SECTION V BASIC GROUND WATER HYDROLOGY FOR THE DESIGN OF SUBSURFACE WASTEWATER ABSORPTION SYSTEMS

A. Introduction

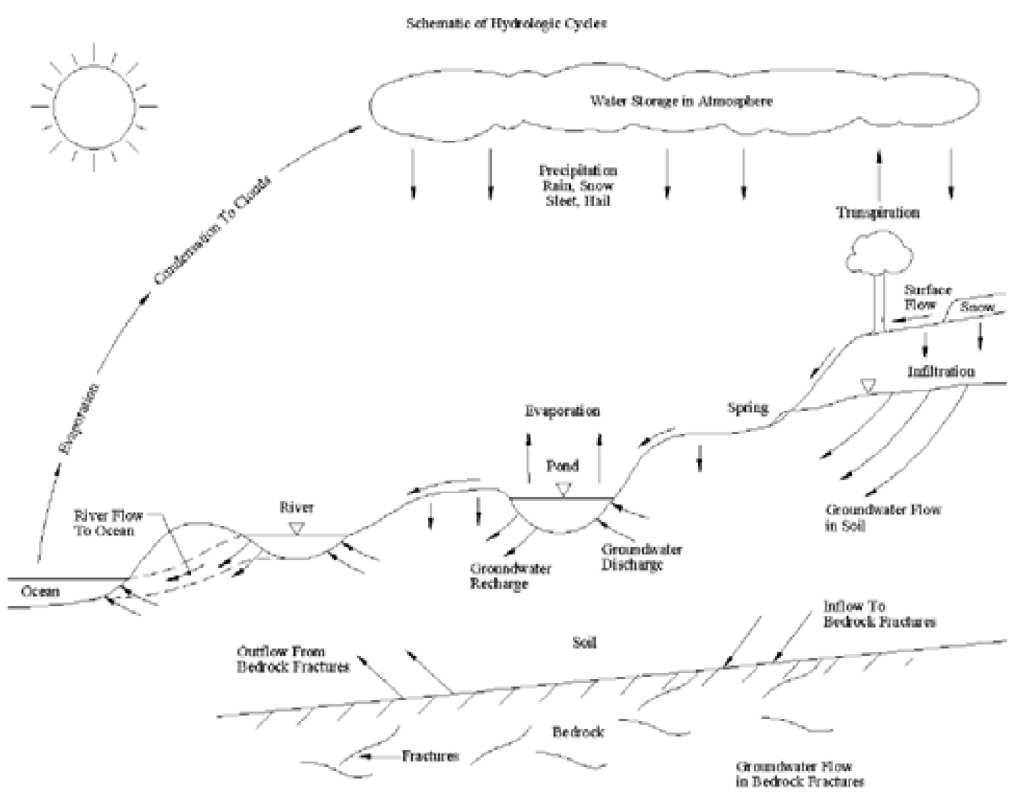
Some knowledge of the basic principles of ground water hydrology must form the background on which an engineer will make decisions about an OWRS.

The hydrologic cycle is the continuous movement of water from the ocean to the land and back. The ocean water is evaporated by the sun, precipitates on the land, and flows back to the ocean under the influence of gravity. As the water moves through this cycle there are many sub-cycles, as shown in Figure No. 1.

Water is stored for varying lengths of time throughout the cycle in the atmosphere, ice, surface water and ground water, but the amount of water in storage at any specific location changes as the weather changes.

FIGURE No. 1

THE HYDROLOGIC CYCLE

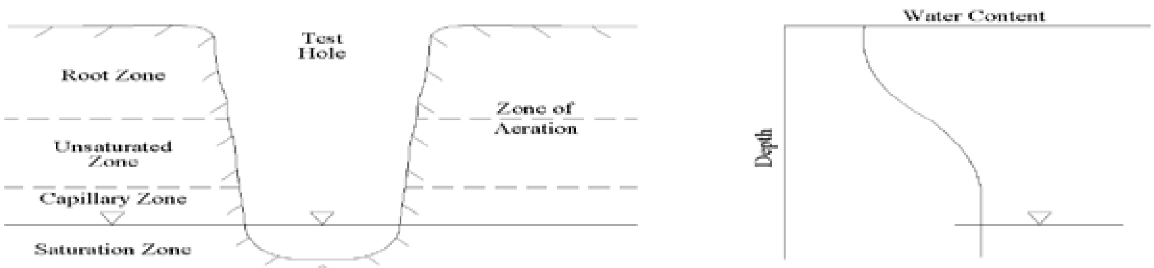


B. Soil Water

Soil is composed of solid mineral particles with voids or pores between them. Precipitation that infiltrates the ground surface may be held near the surface in the root zone or may move downward through a zone of aeration, in which the voids are not filled with water, to the zone of saturation in which the voids are essentially full of water. The Zones are shown in Figure No. 2.

FIGURE No. 2.

SOIL WATER



Within the root zone the water is discontinuous and is held in the form of meniscus between soil particles. The air passages are interconnected and generally continuous throughout the zone. This same situation continues in an unsaturated zone of aeration beneath the root zone, until a capillary zone is reached.

In the capillary zone, the water is drawn up from the saturated zone below by the capillary action in the soil voids. Within this zone, the water is generally continuous and at less than atmospheric pressure. The air is in the form of individual bubbles. This zone may range from less than an inch high in sand to more than 20 feet high in clay.

In the saturated zone what little air exists is in the form of individual bubbles and the water is at a pressure greater than atmospheric. The ground water table, the upper limit of this zone, is by definition the elevation at which the water pressure is atmospheric. It is the elevation to which the water level will rise in a test hole. The majority of the lateral movement of ground water occurs within the saturated zone, There is no sharp demarcation between these three zones, as a plot of water content versus depth in Figure No. 2 indicates.

There are two major purifying processes within the hydrologic cycles**.** Evaporation from the ocean and lakes brings distilled water into the atmosphere. Rain that infiltrates the ground is cleansed by purification that takes place as it passes through the soil. Such purification is accomplished by mechanical filtering, biological activity, and chemical absorption and adsorption. The soil generally does not remove the highly soluble salts. Other purification processes may also take place in wetlands, surface water bodies, etc.

In this document we are concerned primarily with how water enters a subsurface wastewater absorption system (SWAS) area, and how it leaves. Water can enter an area as rain, surface water or ground water, and can leave by evaporation, evapotranspiration, surface water or ground water. If the water is entering an area faster than it is leaving, the amount of water in storage will increase in the form of a rising ground water table or pond level. The opposite occurs if the water is leaving faster than it is entering. Rarely does Q in (Q= Volume/Time) equal Q out so the amount of water in storage is always changing; however, it is convenient and reasonably accurate to solve many hydrology problems by assuming that for a short time period storage is constant.

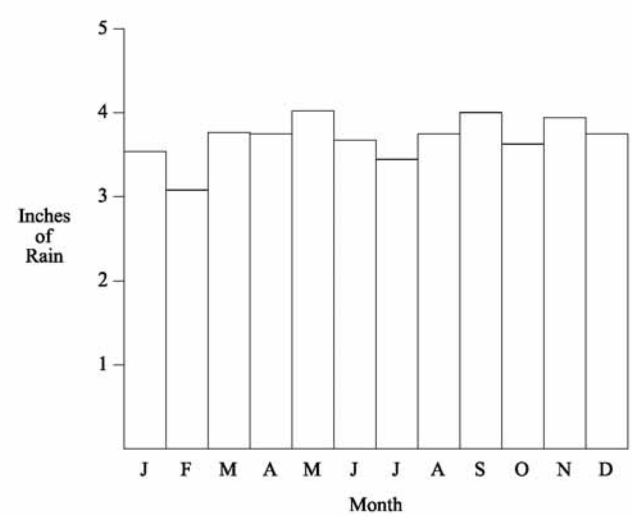
The rate at which water enters and leaves a site varies from day to day but the average value of Q in and Q out over a short period of time can be calculated by taking into account the following factors.

C. Precipitation

The mean monthly precipitation in Connecticut is relatively uniform throughout the year. An example of this uniformity is shown in the bar graph of Figure No. 3.

FIGURE No. 3

MEAN MONTHLY PRECIPITATION AT BRADLEY INTERNATIONAL AIRPORT
(1961-2000)



D. Infiltration

Water on the ground surface either infiltrates the ground or runs off as surface flow to ponds or streams. The infiltration rate depends primarily on the temperature, position of the ground water table, vegetation and type of soil, ground slope and impermeable cover and will vary from season to season. Typical values are given in Table No. 1 for uniform bare soil with the ground water table well below the surface.

TABLE No. 1

TYPICAL INFILTRATION VALUES

Soil Type	Infiltration Rate-in/hour
Sandy soils	0.50-1.00
Clay & silt loams	0.10-0.50
Clays	0.01-0.10

The rate of infiltration for all but clay exceeds the rate of rainfall most of the time, which means that there will be very little surface runoff during moderate rain in unfrozen soil in areas where the ground water is well below ground surface.

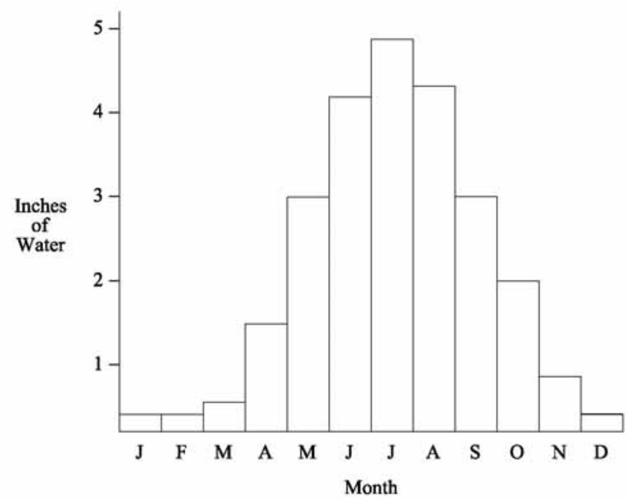
E. Evapotranspiration

Evapotranspiration is the loss of water through evaporation from surface water and vegetation. The rate of evapotranspiration varies greatly throughout the year and depends on the type of vegetation, soil type, and position of the ground water table. The average monthly rate of evapotranspiration for a well-vegetated area in the Northeast is given in Figure No. 4.

If the average monthly precipitation is superimposed on the evapotranspiration chart it can be seen that, in the months of May, June, July, August, and September, the total evaporation exceeds the precipitation and these are the drying months when the pond levels and ground water tables drop. The wet season typically is caused not by more precipitation but by less evapotranspiration.

FIGURE No. 4

AVERAGE MONTHLY EVAPOTRANSPIRATION



F. Surface Flow

When rainfall exceeds the infiltration rate, the water runs off the surface into streams and rivers. Surface flow also occurs when the ground water flow exceeds the capacity of the ground to carry it and the ground water breaks the ground surface. There are many seasonal watercourses that flow only when the melt water and precipitation in the spring exceed the infiltration capacity of the surrounding ground. Surface flow by definition indicates the ground water table is at ground surface so the presence of surface water flow generally precludes the use of such areas for a SWAS without major changes.

G. Ground Water

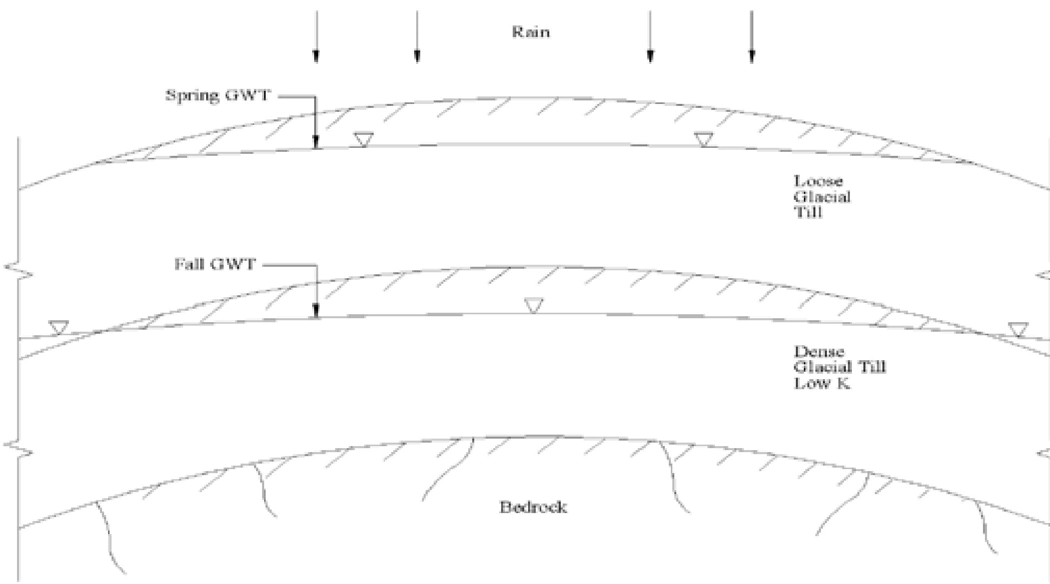
Ground water flows under the forces of gravity through the voids in the soil or rock. In the glaciated areas of New England, the surficial soils are generally much more permeable than the soils or rocks underlying them so that, except in deposits of sand and gravel, most of the ground water flow is parallel to the ground surface and occurs in the top 10-20 feet of soil. The rate at which ground water can enter or leave a site depends on the slope of the water table, the hydraulic conductivity of the soil, and the thickness of the saturated soil. It should be noted that ground water flow in soil voids differs from ground water flow in rock voids; the latter being considerably more difficult to predict.

The hydraulic conductivity of the soil is the greatest variable in ground water flow, and, particularly in New England, the soil can be very heterogeneous within a given area. The effects of heterogeneity on the ground water flow are illustrated in the following figures.

Figure No. 5 shows the cross section of a drumlin composed of glacial till over bedrock. The upper 4-6 feet of the till have been loosened and lightly granulated by frost action air, and bioturbation and its hydraulic conductivity is several hundred times greater than the underlying till, which is still very dense due to the original depositional forces of the glaciers.

FIGURE No. 5

CROSS-SECTION OF A DRUMLIN

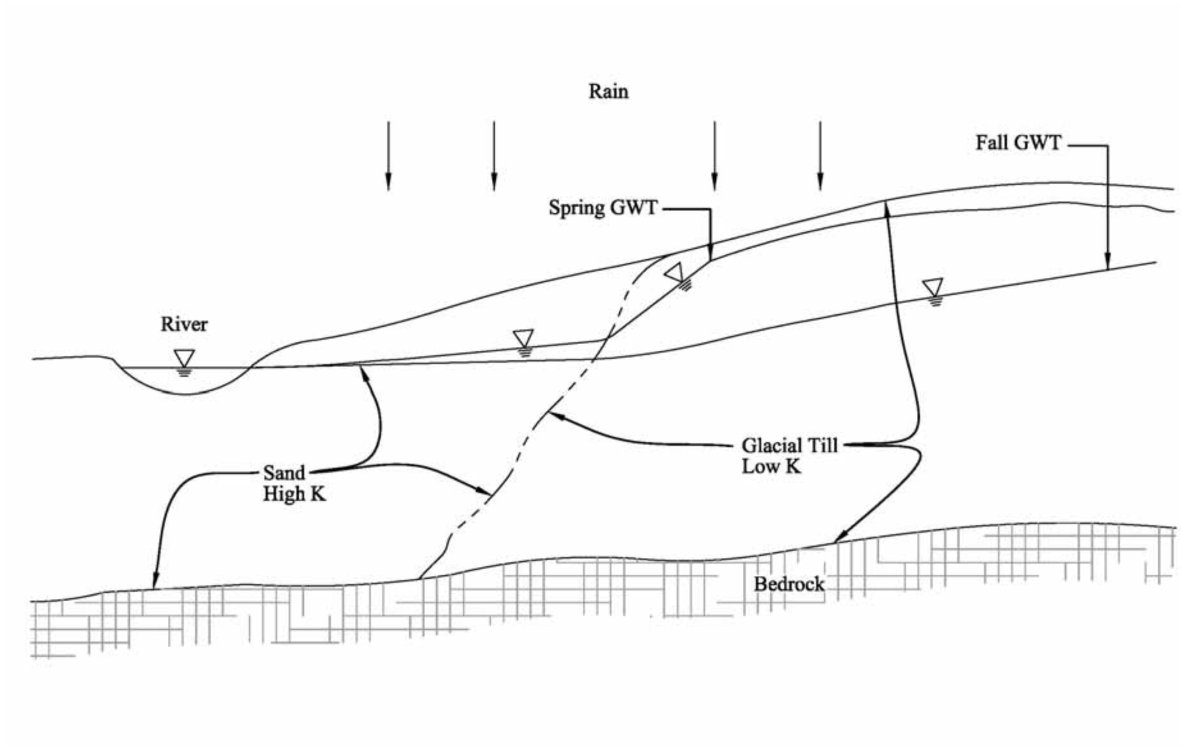


During the wet season, precipitation infiltrates the upper part of the hill faster than it can flow laterally and downward within the soil on the hillside, and the ground water table intersects the ground surface part way down the hill. During the dry summer months, the ground water table gradually drops below the top of the underlying till as the water flows away faster than it is supplied.

Figure No. 6 shows the cross section of a hill with sand and gravel along the river downhill from glacial till. The hydraulic conductivity of the sand and gravel is several hundred times greater than that of the till. During the wet season the ground water that is at the surface of the till can flow easily through the sand and gravel. During the dry season, the water table drops in the glacial till (10-20’) whereas the water table in the sand and gravel drops very little due to the nearness of the river that is supplied with water from a much larger area. During certain periods, the river may be recharging the sand and gravel deposit.

FIGURE No. 6

CROSS-SECTION OF A HILL ABUTTING A RIVER



Discharge of wastewater into a SWAS is a man-made sub-cycle in the hydrologic cycle and follows the same physical laws as other water does. The path that the discharged water will follow can be predicted, based on knowledge of the soil properties and the original hydrologic conditions.

H. References

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