SCOPING DOCUMENT MGWA WHITE PAPER #7: Accounting for the Infuence of Human Factors on Groundwater Recharge Estimates in Minnesota

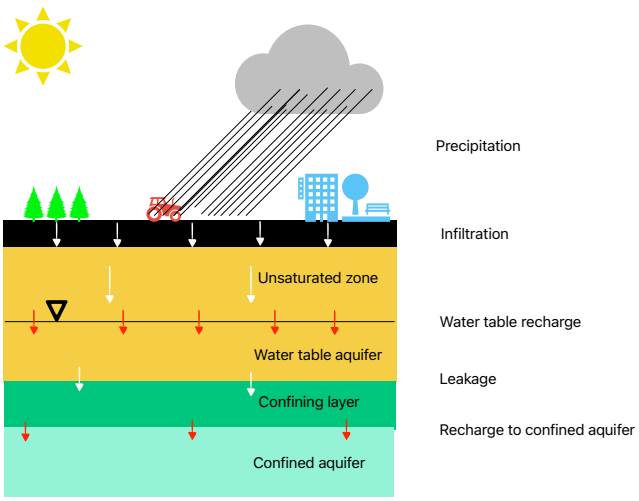
Topic Description

Sustainable groundwater management requires understanding mechanisms controlling groundwater flow, including groundwater recharge. A widely-used text (Freeze and Cherry, 1979) provides a general definition: recharge is "the entry into the saturated zone of water made available at the water-table surface, together with the associated flow away from the water table within the saturated zone." Recharge is rarely known with precision, though it is integral to most hydrogeologic studies, particularly those involving mass balance calculations or groundwater flow modeling.

Two primary components control recharge timing and volume: input (precipitating water), and the water-conducting properties of the container, composed of geologic materials. The output of the process is recharge itself.

Input. Precipitation limits recharge to the water table, and therefore recharge to the water table aquifer can not exceed precipitation. Precipitation is episodic: frequency and intensity vary over short and long time frames.

The passage of precipitating water across the air-soil interface into the unsaturated zone is infiltration. Water travels rapidly through loose geologic materials (sandstone, glacial outwash), and more slowly through tight geologic materials (shale, silty or clayey glacial till). When infiltrating water passes from the unsaturated zone into the saturated zone, recharge occurs. For recharge to aquifers beneath the water table, the analogous input is groundwater lost by upgradient (perhaps overlying) aquifers or confining units. Departures from mean precipitation volume, frequency and intensity affect infiltration amounts and recharge estimates.



Geologic Container. The vertical permeability of natural or non-natural materials within the soil zone approximately five feet thick limit the rate of infiltration. Natural factors that influence vertical permeability in the soil zone include soil texture, soil moisture, vegetative ground cover, and the seasonal presence of frost. Human factors affecting vertical permeability in the soil zone may be related to urbanization or agricultural practices.

Recharge Estimation. For hydrogeologic studies, the impracticality of directly measuring recharge increases reliance upon estimation methods. Recharge estimates may be at local or regional scales. Estimation methods and recharge rates differ signficantly between unconfined and confined settings. Research shows that urbanization and agriculture may affect infiltration and recharge in unexpected ways.

Recharge and Water Quality. Land cover is an important factor affecting the water quality of infiltrating water. Measurements in north-central Minnesota showed that water table nitrate concentrations can be highly sensitive to crop type (e.g., Minnesota Department of Agriculture, 2020). Storm water infiltration ponds are typically designed to optimize the infiltrated water volume, but emerging practice seeks to minimize detrimental impact to infiltrated water quality. Rain gardens are typically designed to increase recharge while minimizing the infiltration of urban pollutants.

Recharge and Human Activity. Human activities affect the physical and chemical processes related to recharge. Global climate change has caused significant changes in precipitation volume, intensity and frequency, in turn affecting the volume and timing of infiltrating unsaturated zone water, and ultimately recharge. Regional land uses related to agriculture and urbanization change the ability of water to infiltrate. Local engineering practices such as stormwater infiltration, soil compaction and agricultural drainage affect recharge locations and amounts. Intentional and unintentional changes to processes related to recharge affect the accuracy of recharge estimates.

Objectives and Content Guidelines

The intended readership for this White Paper includes ground water practitioners conducting hydrogeologic projects involving recharge, and decision-makers concerned with sustainable groundwater management. Text length will be roughly ten to twenty pages in standard format. The writing sub-committee will develop content, using the following general outline:

- Introduction: definition and importance
- Recharge types
- Estimation methods and range of values in Minnesota, including error estimates
- Changes to recharged water caused by human activities
    - Recharge and water quality (e.g. introduction of non-natural components)
    - Mobilization of natural contaminants
    - Induced redox-front behavior
    - Dilution
- State of Minnesota policy regarding recharge
    - Well code
    - Stormwater infiltration, including emerging green technologies that may support sustainable recharge management
    - Aquifer storage and recovery
    - Agricultural drainage
    - Rain gardens
- Data needs
- Conclusion and Reference list

Timeframe for White Paper Preparation

The timeframe for completion is twelve to fourteen months. The White Paper Committee will assist the work group in completing its work within this timeframe.

References

Freeze, R.A. and Cherry, J.A. (1979) *Groundwater*. Prentice-Hall, Inc., Englewood Cliffs

Minnesota Department of Agriculture, Pesticide and Fertilizer Management Division (2020) Byron #1 Field Study, Groundwater Monitoring Report, 9 pp.