Introduction to the North Carolina Groundwater Recharge Map

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Introduction

Since its inception, the North Carolina Division of Water Quality (DWQ) has studied and reported on groundwater occurrence, flow, and availability to provide the public with guidelines and assistance for utilizing and protecting North Carolina’s groundwater resources. The purpose of this report is to introduce and discuss DWQ’s North Carolina Groundwater Recharge Map, which has been compiled with ArcView 3.2 and ArcMap using the methodology outlined in Mew et al. (2002). Recharge estimates were developed and mapped for every county with accessible digital soils data. Current mapping gaps will be filled when needed data become available. Maps from this report are available through the DWQ/Groundwater Planning publications website (http://h2o.enr.state.nc.us/gwp/publications.htm), while respective Geographic Information System (GIS) files may be obtained on request.

Groundwater Recharge Mapping Concepts

The statewide Groundwater Recharge Map is based on several concepts and assumptions concerning groundwater flow, where water flows beneath the land surface from regions of upland recharge to areas of lowland discharge. Groundwater recharge and discharge are influenced by several factors including: regional geology; soil type and infiltration capacity; depth to water table; landscape type and slope; and rainfall. To predict the significance of these recharge factors, digital soil mapping units from county surveys were analyzed to determine landscape units having comparable recharge properties. Then, estimated groundwater recharge rates were assigned to each landscape unit, while groundwater discharge was determined using the Rorabaugh-Daniel model (Rutledge, 1993). Finally, all calculated recharge estimates were weighted using mean rainfall rates (Mew et al., 2003).

Geomorphology

Landscape units are based on soil type and slope and divided into “uplands” and “lowlands” or high recharge areas and lower recharge/discharge areas, respectively. More detailed geomorphic classifications delineate upland flats (coarse and fine textured mineral or organic interstream divides), transitional areas, such as gentle to very steep valley slopes (Demek, 1972), and lowland features such as marine terraces and valley bottoms, which include stream terraces and floodplains. Other landscape designations include barrier islands, urbanized land, surface water (streams and sounds), and miscellaneous units, such as borrow pits and quarries (Figure 1).

These geomorphic classifications are well suited for groundwater mapping purposes, but slightly conflict with current coastal plain geological terminology. The Landscape Map (Figure 1) illustrates a sharp color contrast extending from North to South, along the middle Coastal Plain, showing a transition from either upland wet or dry flats or stream terraces to marine terraces (from west to east, respectively). This distinct geomorphic change occurs along a contour line, 12 meters above mean sea level and coincides partly with surface expressions of the Suffolk Scarp to the northeast and the Walterboro Scarp.
to the south. Farrell (2002), currently conducting Coastal Plain research in North Carolina, geologically defines marine terraces as extending west of the 12-meter contour line and into the upper coastal plain portions of the Neuse, Pamlico, and Chowan River basins. However, for hydrogeological mapping purposes, Mew et al. (2002) defined the westerly limit of marine terraces as terminating at this line, due to stream dissection further westward, which increases slope and changes landscape designation. Additionally, stream dissection lowers the local water table and results in greater available pore space for aquifer storage and groundwater recharge during rainfall events. Thus, a similar line of color contrast for groundwater recharge is depicted in the Groundwater Recharge Map (Figure 2).

**Hydrogeology**

Groundwater recharge mapping results depend largely on landscape unit designation and local rainfall. Cursory review of the Groundwater Recharge Map (Figure 2) reveals upland recharge areas between streams, and lowland areas of lower recharge and discharge at or near stream channels. However, more specific trends may also be determined. For example, analysis of average annual statewide rainfall distribution depicts the highest rainfall concentrations in the mountainous western portion of North Carolina (Figure 3). High rainfall rates, probably resulting from maritime influences, also occur along the southern coastal plain, but are still significantly less than in the west.

The local rainfall trend is somewhat reflected in the Groundwater Recharge Map, which depicts high recharge rates for much of the inner coastal plain and the mountains. However, western North Carolina geomorphology is dominated by moderate to steep slopes, while the inner and southeastern outer coastal plain is largely composed of upland flats and gentle slopes. Therefore, while high rainfall is an important factor in groundwater recharge, landscape setting seems to have a greater influence on infiltration, recharge, and storage. This principle is further reinforced when analyzing coastal plain landscape units and recharge estimates (Figures 1 and 2). For instance, some geological deposits on either side of the 12-meter contour line exhibit similar lithology, but differ in landscape setting and recharge rate. Deposits to the west of the line are classified as uplands and drained by streams. Geologically similar deposits east of the line have a comparable infiltration capacity, but are not significantly dissected by fluvial channels, which appreciably drain the phreatic zone. Here in these lowlands, the water table is closer to the land surface, which allows for less available pore space for groundwater recharge and storage. This further illustrates the concept of higher groundwater recharge in uplands and lower recharge and subsequent discharge in lowlands.
Figure 1. North Carolina Landscape Units. Landscapes are further defined as being Coastal Plain (CP), Slate Belt (SB), Triassic Basin (TR), coarse textured (ct), or fine textured (ft) features, based on Mew et al. (2002).
Figure 2. North Carolina Groundwater Recharge Map.
Figure 3. North Carolina Rainfall Distribution. The average annual rainfall presented here is based on information from Hirth (1998), which was integrated into the groundwater recharge data tables and shape files. As with Figures 1 and 2, counties without digitized soils data are not included in this data set and are therefore shown with the color white.
Underlying geology also plays an important role in local soil type, landscape setting, and consequently, groundwater recharge (Mew et al., 2002). This is well illustrated in a review of the Neuse River Basin (Figures 4 and 5), which trends roughly northwest to southeast and extends from the Carolina Slate Belt, through the Triassic Basin, and into the Coastal Plain. Perhaps the best example of the relationship of geology to recharge in the Neuse River Basin is the comparison of the Triassic Basin to upland coastal plain recharge rates. Here, the fine-grained material of the Triassic Basin allows for much less infiltration and storage than does the more coarsely grained southeastern upland coastal plain.
Figure 5. Neuse River Basin Groundwater Recharge.

Conclusions and Recommendations

The North Carolina Groundwater Recharge Map (Figure 2) is a useful tool to assist citizens, businesses, and community planners with groundwater use and protection concerns. This research has quantified the relationship of landscape, geology, soil type, and rainfall to groundwater recharge and illustrates the premise of groundwater flow from upland areas of high recharge to lowland areas of lower recharge and discharge. The integration of these data with GIS allow landscape and recharge maps to be used at all scales, ranging from a small, local drainage basin or a county, up to the full extent of the state. Unfortunately, county boundary edge matching issues exist and are noted as thin, white areas in the figures. This results from data being digitized by local counties, where no uniform political border with contiguous counties is used. DWQ has been working to correct these discrepancies. Additionally, data gaps exist, particularly from some of the western counties, where digital soils information has yet to be compiled. Future research should integrate new digital soils coverage to refine landscape designations and recharge estimates for both unmapped and mapped areas. Updated maps will subsequently be accessible through the DWQ/Groundwater Planning website.
References


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