Hydrology
Long Island's Aquifer Systems

Long Island Aquifers

Overview of Long Island Physiography and Water Budget

Long Island is a closed hydrogeologic system, with all recharge coming from precipitation falling on the surface of the island and discharge to streams, wells, and as subsea outflow.

Inputs (million gallons per day)

<table>
<thead>
<tr>
<th>Input</th>
<th>Rate (mgd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average precipitation</td>
<td>1,600</td>
</tr>
<tr>
<td>Evapotranspiration</td>
<td>795</td>
</tr>
<tr>
<td>Direct runoff</td>
<td>20</td>
</tr>
<tr>
<td>Infiltration</td>
<td>785</td>
</tr>
</tbody>
</table>

Data from USGS Groundwater Atlas

Outflows (million gallons per day)

<table>
<thead>
<tr>
<th>Outflow</th>
<th>Rate (mgd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseflow</td>
<td>320</td>
</tr>
<tr>
<td>Subsea Outflow</td>
<td>450</td>
</tr>
<tr>
<td>Evapotranspiration</td>
<td>15</td>
</tr>
</tbody>
</table>

Total freshwater storage beneath Long Island is estimated to be between 3 and 6 trillion gallons.

As of 1985, 2.8 million residents were withdrawing an average of 470 mgd of freshwater from the aquifer system.

Because Long Island is bordered on all sides by salt water bodies, the groundwater beneath the island forms a freshwater lens bordered by a freshwater-saltwater interface zone.

Topographically, Long Island consists of two morainal ridges that diverge to the east to form the North Fork and South Fork. Between and south of these ridges are gently sloping to flat regions of glacial outwash. The main topographic high of Long Island runs along the northern half of the island from the Queens / Nassau border to central Suffolk County. This elevated region is bisected by a north-south valley carved by glacial meltwater streams, with the highest region located west of the valley.

Long Island receives an average of about 45 in/yr of precipitation, with a mild orographic effect causing a difference in precipitation of as much as 10 inches between low points near the southern shoreline and highs to the north.

The overall pattern of flow for groundwater under Long Island is dictated by the topography: Recharge is associated with high head values in the elevated north-central region of the island, which forms a groundwater divide. Flow is to the north and south of the elevated central region, with discharge along both shorelines.
Stratigraphy and Aquifers

Long Islands' hydrostratigraphic units (aquifers and confining layers) are formed from surficial glacial deposits (tills and outwash sands) of Pleistocene age which unconformably overlie older deposits of Cretaceous age developed on the slowly subsiding coastal plain. These deposits are bounded at the bottom by an impermeable bedrock surface consisting of crystalline metamorphic rock of the Lower Paleozoic. The bedrock surface dips to the southeast, so that the coastal plain aquifer units thicken from a feather edge under Long Island Sound to more than 2000 ft. along the southern margin of Long Island.

Three principal aquifers are present under Long Island, along with several other locally developed aquifers, some of which are yet unnamed.

Upper Glacial Aquifer: The glacial sands and gravels that the island is built from form a large unconfined surficial glacial aquifer. This aquifer is recharged directly by rainfall on Long Island. Horizontal hydraulic conductivity in the Upper Glacial aquifer averages 270 ft/day.

Magothy aquifer: a sequence of sands sandwiched within discontinuous layers of clay that act as localized aquitards. However, over most of its extent, the Magothy behaves as an unconfined aquifer in hydrologic connection with the Upper Glacial. Horizontal hydraulic conductivity in the Magothy aquifer averages 50 ft/day. The Magothy is recharged directly by downward flow from the Upper Glacial Aquifer.

Lloyd aquifer: a deep sand and gravel aquifer separated from the overlying Magothy aquifer by an interval of clay called the Raritan clay. Horizontal hydraulic conductivity in the Lloyd aquifer averages 40 ft/day, whereas horizontal hydraulic conductivity in the Raritan confining unit is only .01 ft/day. The Lloyd aquifer is recharged by leakage across the confining unit beneath the north-central region of Long Island, near the groundwater divide.

Other Hydrogeologic Units

Jameco Aquifer: this is a fourth aquifer, locally developed in gravels infilling Pleistocene valleys in Kings and Queens counties. This aquifer is confined by a widespread marine clay called the Gardiners Clay. The Jameco is rarely pumped and is not considered an important groundwater resource.

Monmouth Greensand: this is an uppermost layer of Cretaceous age, glauconitic clay that forms a confining unit over the southern extent of the Magothy aquifer across central Long Island. It is located primarily under the Great South Bay and does not have much of an impact on groundwater use.
Groundwater Flow Under Long Island

Groundwater flow through the aquifers beneath Long Island begins as recharge in the Upper Glacial. Because vertical hydraulic conductivity is an order of magnitude less than horizontal hydraulic conductivity in all three aquifers, water flows outward from the zone of recharge much faster than it flows downward. Nevertheless, because of an overall decreasing hydraulic gradient with depth in the central region of the island, some groundwater flows downward from the Upper Glacial to recharge the Magothy, and some of this recharge also crosses the Raritan confining unit to recharge the Lloyd aquifer. Toward the north and south shores the vertical hydraulic gradient reverses and groundwater flows upward to discharge as subsea outflow in the Atlantic Ocean and in Long Island Sound.

Upper Glacial: The water table developed in the Upper Glacial aquifer generally follows the topography of Long Island, with highs of 80 ft above sea level in northwestern Suffolk and northeastern Nassau counties. Flow is radially outward from the water table highs, spreading generally north and south to the respective shorelines. Cones of depression in the water table are seen in northeastern Queens county, where overpumping of the Upper Glacial has occurred in the past.

Magothy: The potentiometric surface of the Magothy aquifer is broadly similar to the Upper Glacial, demonstrating that the two are hydrologically connected. Head values for the Magothy are a few feet less than the Upper Glacial, indicating a downward hydraulic gradient in the region of recharge. A large cone of depression exists in Queens due to previous overpumping of the aquifer.

Lloyd: The Lloyd aquifer potentiometric surface is broadly lobate, with a zone of recharge seen in the north-central region of the island. A very large cone of depression is present in Queens and Kings counties due to overpumping.

Recharge Areas

The Upper Glacial aquifer can accept infiltration along its entire surface area, although flow paths are relatively shallow away from the elevated region of the island that forms the main recharge area. Flownet models of the Long Island aquifer system indicate that only steep flowlines emanating from belt of recharge approximately 5 miles wide are able to penetrate down into the Magothy aquifer. 64% of recharge to the Upper Glacial discharges without entering the Magothy. The belt of recharge for the Lloyd is only .5 miles wide and only 3.1% of recharge is able to recharge the Lloyd, traversing the Raritan confining unit over a distance of 11 miles.

Rates of Groundwater Movement

Flow models have been developed to estimate the rate of flow of groundwater through Long Island's aquifer system. Recharge from the Upper Glacial can reach the Magothy in a few years or less. It takes almost 100 years for water to penetrate through the Magothy to the Raritan confining unit, and another 100 years to cross the Raritan clays. Flow
within the Lloyd is very slow, with groundwater taking as much as 3000 years to penetrate deep into the southern reaches of the Lloyd.

**Groundwater Quality**

The mineral composition of the aquifers beneath Long Island is mostly quartz, which contributes very little to the groundwater in the form of dissolved solids. However, in the Magothy and Lloyd, iron minerals are present and can lead to excessive concentrations of dissolved iron in some areas. Dissolved iron gives water an unpleasant, rusty taste and causes iron oxide buildups in pipes and water heaters. Also, groundwater is naturally acidic due to dissolved CO$_2$ and organic acids picked up from soils. There are no carbonate minerals under Long Island to buffer this acidity, thus Long Island groundwater commonly has a pH less than 6, making it very corrosive.

Saltwater mixes with freshwater by diffusion along an interface near the coastlines of the island. Near the interface the concentration of dissolved solids increases markedly, particularly sodium and chloride. Normally, the position of the interface is relatively stable, however, pumping has reversed the normal hydraulic gradient in some parts of Kings, Queens, and Nassau Counties, resulting in wedges of saltwater being actively pulled into the freshwater aquifer system.