# Compilation of the 1:100,000-Scale Surficial Geologic Map and Database, Kittery 100K Quadrangle, New Hampshire

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**Abstract**

This report describes the surficial geology and Quaternary history of the New Hampshire portion of the Kittery 30'x60'-minute quadrangle, located in southeastern New Hampshire. Surficial earth materials include unconsolidated sediments (till, sand, gravel, etc.) of glacial and nonglacial origin. Most of these deposits formed during and after the most recent glaciation by the late-Wisconsin Laurentide ice sheet, the last continental glacier to advance over and retreat from the area. Surficial sediments cover the bedrock over hillsides and valley bottoms in the quadrangle and are subject to various land-use considerations. These include sand and gravel extraction, development and protection of ground-water supplies, siting of waste disposal facilities, selection of building sites, and agriculture.

The map compilation for this study was carried out by the authors in support of the STATEMAP cooperative between the New Hampshire Geological Survey and the U. S. Geological Survey (USGS). The geologic map accompanying this report shows the distribution of sedimentary deposits, and indicates their age, composition, and known or inferred origin. It also includes information on the geologic history of the quadrangle, such as features indicating the flow direction of glacial ice. This map provides the basis for the discussion of glacial and postglacial history presented here.

**Introduction**

This 1:100,000-scale 30'x60' surficial geologic map is a compilation of 8 previously mapped 1:24,000-scale 7.5' surficial geologic maps, of which 4 were published by the New Hampshire Geological Survey and 4 were published by the United States Geologic Survey (USGS) in partial fulfillment of STATEMAP deliverables (Figure 1). The original mapping was completed between 1989 and 2005 by a variety of geologists (Table 1). This compilation project was recommended and approved by the New Hampshire Geologic Resource Advisory Committee to satisfy stakeholders' needs for seamless geologic map data. The map is provided as a high-resolution PDF as well as in ESRI geodatabase format following USGS's data standard, Geologic Map Schema (GeMS). The deliverables include open-source-readable files such as GIS shape files, Microsoft Excel spreadsheets, and text files for all users. Maps, map pamphlets, and GIS data may requested from the New Hampshire Geological Survey via email to geology@des.nh.gov.

**Methods**

Previously published and digitized 1:24,000-scale 7.5' map unit GIS polygons were merged and consolidated into 15 surficial units using depositional environment and age categories defined by the original mapper in an effort to remain consistent with the original data and field relationships. In order to achieve an internally consistent map without redundancies and ambiguities, several slight modifications were made. For example, bedrock polygons originally mapped as “br” were too small and few in number to map at this scale, so they were consolidated into the thin till unit (Ptt), which consists of both thin till and abundant bedrock outcrops.

The original 7.5-minute map publications were in various levels of cartographic completion and not all followed the same standard format. Preparing new publication-ready PDFs for each original 7.5’ map was outside of the scope of the project. However, because the authors realize that map users may compare this compilation to the original publications, the GIS data include a crosswalk between original map units and their new designations in this compilation. That information is stored in the field “Original_MapUnit” in the feature class or shapefile “MapUnitPolys”. The depositional environment information is on the map and stored in the field “DEP_ENV” in the “DescriptionOfMapUnits” table.

The map unit symbols/labels follow a consistent naming scheme. Geologic map unit symbols begin with a capital letter for age distinction (H, P, or Q for Holocene, Pleistocene, and Quaternary, respectively). Lower case letters stand for depositional environment (Depositional environment categories include alluvial, palustrine (wetland), eolian, glaciolacustrine and glaciofluvial. Subcategories of alluvium include active alluvium (Ha) and stream terraces (Qst). Subcategories of glaciomarine deposits include undifferentiated (m) and deltaic (md). Ice-contact deposits and glacial lake sediments are not differentiated and combined into a glaciofluvial and glaciolacustrine (fl) unit. Subcategories of the marine Presumpscot Formation (p) are the sandy facies (ps) deposited in a shallow water environment, and the clay facies (pc) deposited in deeper water.

Many of these maps were published prior to the availability of statewide 1-meter or sub-meter resolution LiDAR data and were mapped on 1:24,000-scale topographic base maps. The statewide Water Well Inventory, maintained by New Hampshire Department of Environmental Services, was used to update the thin till layer systematically across the map using reported depth of bedrock. Steps were taken during the compilation process to assess the accuracy of these geologic map units in comparison to the LiDAR. However, due to the scope of this project, limited steps were taken to align the GIS to the LiDAR. The accuracy of the map unit polygons is generally less than 100 feet, although higher inaccuracies may occur.

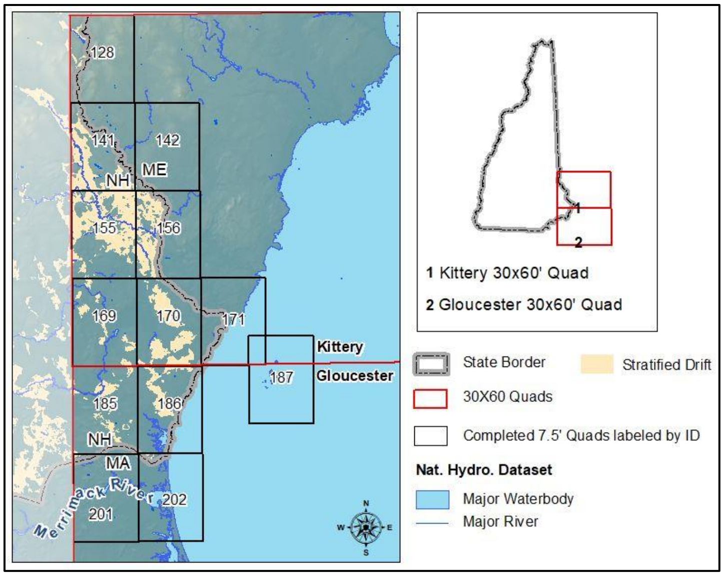


**Figure 1. Index map of compiled 1:24,000-scale geologic surficial maps**

**Table 1. Summary of compiled 1:24,000-scale geologic surficial maps**

| **Kittery 30x60-minute sheet** | | | |
|---|---|---|---|
| **Quad ID** | **7.5-minute Quadrangle** | **Year Published** | **Author** |
| 128 | Milton | 2005 | Koteff/Larson |
| 141 | Rochester | 1991 | Koteff |
| 142 | Somersworth | 1991 | Koteff |
| 155 | Dover West | 1989 | Koteff/Goldsmith/Gephart |
| 156 | Dover East | 1989 | Larson/Goldsmith |
| 169 | Newmarket | 2005 | Franzi/Wittkop/Koteff |
| 170 | Portsmouth | 1992 | Larson |
| 171 | Kittery | 1992 | Larson |

## Surficial Geologic History of the Kittery 30’x60’ Quadrangle, New Hampshire

Surficial deposits include unconsolidated to weakly consolidated deposits overlying bedrock. In the New Hampshire portion of the Kittery 30’x60’ quadrangle, bedrock includes igneous, metaigneous and metasedimentary rocks of Ordivician-Cambrian to Devonian age (Hussey et al., 2016). The surficial geology of the Kittery quadrangle in New Hampshire is primarily the result of glacial and post-glacial activities in the area during the Pleistocene and Holocene epochs, respectively. When the Laurentide Ice Sheet advanced over the area, it mobilized and re-deposited a great quantity of unconsolidated material. Those materials, known as surficial deposits, can be classified into two major categories based on whether the deposits were transported in or deposited by moving water.

Those deposits deposited directly beneath the ice mass or dropped out of suspension into disorganized piles of debris are referred to as glacial till (Pt or Ptt). Those deposits transported by or deposited in water are referred to as stratified drift. Till, a poorly sorted and unstratified mix of clay to boulder size clasts within a relatively fine matrix, is present as a mantle of varying thickness directly above bedrock and underlying other surficial deposits across the map area.

Recent work utilizing annual layers in glacial lake sediments (known as varves) in the Merrimack River valley, in concert with radiocarbon dating, suggests the Laurentide Ice Sheet began its retreat from southern New Hampshire approximately 16,000 calendar years ago (Ridge et al., 2012). The movement of the Laurentide Ice Sheet across the landscape also shaped the morphology of the area. Streamlined hills of till or drumlins, with long axes aligned with the dominant direction of ice flow, reflect the shaping of the landscape by the moving ice mass. Some exposures of bedrock also retain striations that formed as the ice and entrained materials scraped across the surface. Many such drumlins and striations are shown on the map and record ice movement from the northwest to the southeast.

Moraines, or ridges of till oriented parallel to the front of the ice sheet that indicate ice-margin positions, are present in the Kittery 30’x60’ quadrangle as regularly spaced, low-relief ridges interpreted to be De Geer moraines. The De Geer moraines are thought to have formed as products of annual oscillations during recession of the Laurentide Ice Sheet in a glaciomarine setting (Sinclair et al., 2018). The presence of De Geer moraines in southeastern New Hampshire was not recognized until the publication of high-resolution LiDAR data for the Seacoast region of New Hampshire in 2008 (Figure 2).

Stratified drift deposits form the major sand and gravel deposits within the Kittery 30’x60’ quadrangle. These deposits were carried away from the receding glacier by meltwater and deposited in marine (ocean), fluvial (rivers), or lacustrine (lake) environments. All stratified drift deposits having undergone some degree of sorting and have become well-rounded by the action of moving water. Coarser materials are generally found near the ice margin (proximal environment) where meltwater energy is the greatest. The further from the ice margin one proceeds, the finer the material that can be carried, so deposits become finer away from the ice margin (distal environment).

Relative sea level fluctuations in the map area during and after the last glaciation were controlled by the interplay of eustatic sea level rise from addition of water from the melting Laurentide Ice Sheet and isostatic rebound of the land surface after the retreat of the Laurentide Ice Sheet During the Last Glacial Maximum (26,500 to 19,500 years ago), all of the map area was covered by the Laurentide Ice Sheet (Clark et al., 2009). As the Laurentide Ice Sheet retreated inland, the ice sheet stayed in contact with the sea. Coastal lowlands in New England were inundated to a present-day elevation of 300 to 320 feet (91 to 98 meters) in the map area (Tinkham, 2005). Isostatic rebound of the recently deglaciated areas as

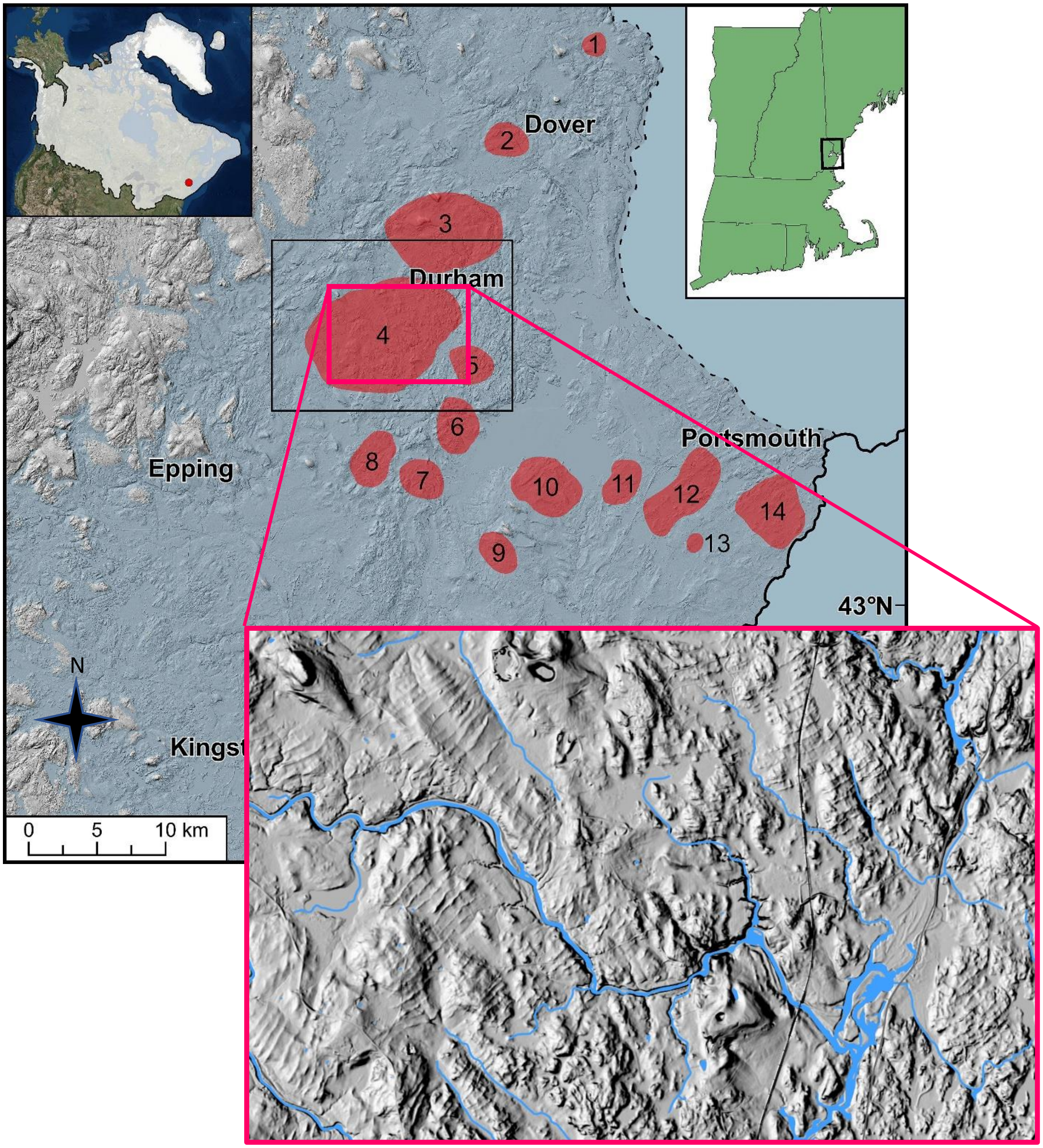


*Figure 2 – Location map of the Seacoast region of New Hampshire indication the distribution of De Geer moraines, modified from Figure 1 of Sinclair et al., 2018. Top left inset panel show the maximum extent of the Laurentide Ice Sheet in North America. Blue shading indicates the marine limit during the late-Pleistocene. Red polygons indicate identified swarms of De Geer moraines in the Seacoast region of New Hampshire. Detail inset (pink) shows high-resolution LiDAR multidirectional hillshade of the regularly spaced, low-relief De Geer moraine swarm in Durham and Newmarket*

the ice sheet retreated inland led to a sea-level regression to a low stand of -180 feet (-55 meters) compared to modern sea level (Barnhardt et al., 1995). As relative sea level continued to rise due to the continued addition of meltwater, the marine transgression resumed to present-day sea levels.

In the southern end of the Kittery 30'x60' Quadrangle, the stratified deposits were laid down in a marine setting as wave-modified nearshore or beach deposits (Pm), or as deltaic deposits (Pmd). As the ice receded from the area, the ocean maintained contact with the ice until a point about one mile south of Milton. The late-Pleistocene marine limit presently lies at an elevation of approximately 300 to 320 feet (91 to 98 meters) above present-day sea level (Tinkham, 2005). Submarine sand, silt, and clay of the Presumpscot Formation were deposited in the synglacial sea in an estuarine environment as shallow-water deposits (Pp or Pps), or as deep-water deposits (Pp or Ppc).

Above the marine limit in the higher terrain near the northern limit of the Kittery 30'x60' Quadrangle, non-marine glaciofluvial ice contact deposits and glaciolacustrine deposits (Plf) are found. Some such deposits are related to Glacial Lake Milton which formed in an ice-dammed area within the present Salmon Falls River and Branch River Valleys. Meltwater from the ice sheet carried material into the lake creating large deltas and lake bottom deposits (Tinkham, 2005). Other glaciofluvial deposits in the form of eskers were formed within tunnels in the melting ice mass and remain as steep-sided, narrow piles of coarse-grained debris.

Extensive re-working of the glacial deposits by post-glacial streams and rivers cut stream terraces (Qst) in many locations, which now stand above the level of the existing rivers and streams. Alluvial deposits (Ha) are still being created by the on-going work of present-day streams as they continually erode and deposit unconsolidated material within the quadrangle. Many of the wetlands that exist today (Hw) formed in areas that were previously stream channels or locations where stagnant ice blocks melted away leaving lakes and ponds that continue to be filled in to this day. Deposits near the modern coastline formed by ongoing near-shore processes include sandy beach deposits (Hb) and marine estuary deposits (Hme).

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