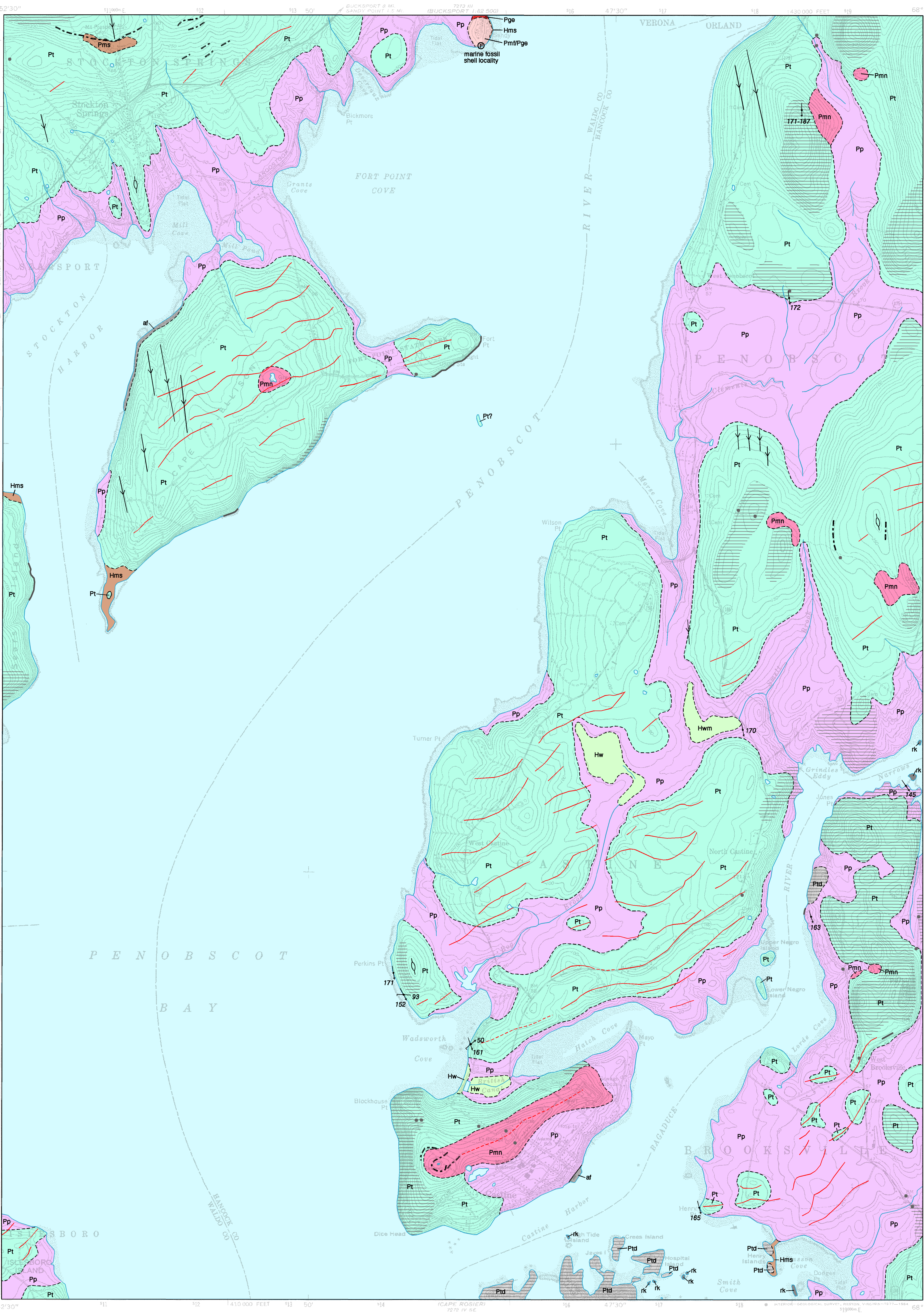
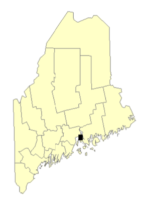
# Surficial Geology





Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 10 FEET

TRUE NORTH

### SOURCES OF INFORMATION

Surficial geologic mapping of the Castine quadrangle was conducted by Woodrow B. Thompson during the 2012 field season. Funding for this work was provided by the U. S. Geological Survey STATEMAP program and the Maine Geological Survey, Department of Agriculture, Conservation and Forestry.

Topographic base from U.S. Geological Survey Castine quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

**Hw** — **Wetland deposits** - Peat, muck, silt, and clay in poorly drained areas.

**Hwm** — **Wetland** - Grassy marshland area.

**Hms** — **Marine shoreline deposits** - Sand and gravel on modern ocean beaches.

**Pmn** — **Marine nearshore deposits** - Sandy to gravelly sediments formed in late-glacial time, when waves and currents reworked glacial deposits during regression of the sea.

**Pms** — **Marine shoreline deposits** - Sandy to gravelly sediments formed in late-glacial time when marine processes reworked glacial deposits along contemporary shorelines. The upper limit of marine submergence in the Castine area was at an elevation of about 300 ft (91.4 m) in the northern part of the quadrangle.

**Pp** — **Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the sea floor during marine submergence of coastal lowlands in late-glacial time. This map unit commonly overlies the irregular surface of glacial till in a complex manner, so it is likely to include areas of till exposed at the ground surface.

**Pmf/Pge** — **Glaciomarine fan deposits (Pmf) overlying esker gravel (Pge)** - Area where sand and gravel deposited as a submarine fan at the glacier margin overlies esker gravel deposited by subglacial meltwater stream. This association occurs on Sandy Point near the north edge of the quadrangle.

**Pge** — **Esker** - Sand and gravel deposited by glacial meltwater flowing in a tunnel beneath the ice.

**Pt** — **Till** - Loose to very compact, poorly sorted, massive to weakly stratified mixture of sand, silt, and gravel-size rock debris deposited by glacial ice. Boulders are commonly scattered across the ground surface. Till in the Castine Quadrangle reaches a thickness of 135 ft or more. This map unit includes areas of till overlying bedrock and former marine shorelines, as well as patches of overlying Presumpscot Formation (unit Pp).

**Ptd** — **Thin drift, undifferentiated** - Areas of thin patchy sediment cover on bedrock, which are unmapped or have few exposures of surficial materials. The sediments may include till, Presumpscot Formation, and/or marine nearshore deposits.

**Bedrock outcrops/thin-drift areas** - Ruled pattern indicates areas where bedrock outcrops are common and/or surficial sediments are generally less than 10 ft thick. Mapped from ground observations, air photos, and LiDAR (Light Detection And Ranging) imagery. Actual thin-drift areas probably are more extensive than shown. Dots mark locations of individual outcrops. "rk" areas are mostly exposed bedrock ledges.

**af** — **Artificial fill** - Variable mixtures of earth, rock, and/or man-made materials used as fill for roads, railroads, or docks. Usually shown only where large enough to affect the contour pattern on the topographic map.

**Contact** - Boundary between map units. Most contacts are approximately located and therefore indicated by dashed lines.

**Marine shoreline** - Line indicates a former shoreline formed in late-glacial time, when relative sea level was higher than today. Mapped from LiDAR imagery.

**Moraine ridge** - Line shows crest of moraine ridge deposited along the retreating margin of the most recent glacial ice sheet. Composed of till and/or sand and gravel. Dashed where identity is uncertain. Mapped from field observations and LiDAR imagery. Many moraines are revealed by LiDAR, but some of them are low subtle features that are not readily apparent on the ground.

**Glacially streamlined hill** - Symbol shows long axis of hill or ridge shaped by flow of glacial ice, and which is parallel to former ice-flow direction.

**Fluted till** - Narrow ridge of till shaped by flow of glacial ice. Symbol indicates length and direction of the ridge crest.

**Glacial striation locality** - Arrow shows ice-flow direction(s) inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction. At sites where two or more sets of striations are present and relative ages could be determined, the flagged arrows indicate the older flow directions.

**Marine fossil shell locality.**

### USES OF SURFICIAL GEOLOGY MAPS

A surficial geology map shows all the loose materials such as till (commonly called hardpan), sand and gravel, or clay, which overlie solid ledge (bedrock). Bedrock outcrops and areas of abundant bedrock outcrops are shown on the map, but varieties of the bedrock are not distinguished (refer to bedrock geology map). Most of the surficial materials are deposits formed by glacial and deglacial processes during the last stage of continental glaciation, which began about 25,000 years ago. The remainder of the surficial deposits are the products of postglacial geologic processes, such as river floodplains, or are attributed to human activity, such as fill or other land-modifying features.

The map shows the areal distribution of the different types of glacial features, deposits, and landforms as described in the map explanation. Features such as striations and moraines can be used to reconstruct the movement and position of the glacier and its margin, especially as the ice sheet melted. Other ancient features include shorelines and deposits of glacial lakes or the glacial sea, now long gone from the state. This glacial geologic history of the quadrangle is useful to the larger understanding of past earth climate, and how our region of the world underwent recent geologically significant climatic and environmental changes. We may then be able to use this knowledge in anticipation of future similar changes for long-term planning efforts, such as coastal development or waste disposal.

Surficial geology maps are often best used in conjunction with related maps such as surficial materials maps or significant sand and gravel aquifer maps for anyone wanting to know what lies beneath the land surface. For example, these maps may aid in the search for water supplies, or economically important deposits such as sand and gravel for aggregate or clay for bricks or pottery. Environmental issues such as the location of a suitable landfill site or the possible spread of contaminants are directly related to surficial geology. Construction projects such as locating new roads, excavating foundations, or siting new homes may be better planned with a good knowledge of the surficial geology of the site. Refer to the list of related publications below.

### OTHER SOURCES OF INFORMATION


1. Thompson, W. B., Prescott, G. C., Jr., and Foley, M. E., 2013, Surficial materials of the Castine quadrangle, Maine: Maine Geological Survey, Open-File Map 13-9.
2. Neil, C. D. and Foley, M. E., 2006, Significant sand and gravel aquifers of the Castine quadrangle, Maine: Maine Geological Survey, Open-File Map 06-13.
3. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).
4. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.


# Castine Quadrangle, Maine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Funding for the preparation of this map was provided in part by the U. S. Geological Survey STATEMAP Program, Cooperative Agreement No. G12AC20185.



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**Open-File No. 13-8**
**2013**


### SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 1.5 million and 10,000 years ago. The slow-moving ice superficially changed the landscape as it scraped over mountains and valleys, eroding and transporting boulders and other rock debris for miles. The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments in the Castine quadrangle.

The most recent "Ice Age" in Maine began about 30,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock, and they are important indicators of the direction of ice movement. Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 calendar years ago, soon after it reached its southernmost position on Long Island (Ridge, 2004). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by about 16,000 years ago (Borns and others, 2004). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present elevations of up to 420 feet in the central part of the state.

Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin. Sand and gravel accumulated as deltas and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Ages of these fossils tell us that ocean waters covered parts of Maine until about 13,000 years ago. The land rebounded as the weight of the ice sheet was removed, forcing the sea to retreat.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared. Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines) were constructed along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus. Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat.

The last remnants of glacial ice probably were gone from Maine by 12,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land, and worldwide sea level is gradually rising against Maine's coast.

### References Cited


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Stone, B. D., and Borns, H. W., Jr., 1986, Pleistocene glacial and interglacial stratigraphy of New England, Long Island, and adjacent Georges Bank and Gulf of Maine, in Sibrava, V., Bowen, D. Q., and Richmond, G. M. (editors), Quaternary glaciations in the northern hemisphere: Quaternary Science Reviews, v. 5, p. 39-52.


**Figure 1:** Glacial grooves trending south-southeast (163°) on sloping ledge surface near Perkins Point in Castine. Arrow indicates ice-flow direction.

**Figure 2:** View looking east (and obliquely downward) at bedrock outcrop showing two glacial flow directions, east shore of Wadsworth Cove in Castine. One side of the outcrop (upper-right part of photo) is lower and was protected from the onslaught of the last ice sheet. This part of the ledge preserves crag-and-tail erosion marks showing unusual earlier ice flow toward the northeast (050°). The lower-left side is higher and was fully exposed to erosion by the most recent ice flow, which was toward the south-southeast (155-161°).

**Figure 3:** Glacially scoured bedrock outcrops are common on the tops of Maine hills and mountains. The crest of this hill in Penobscot has abundant ledge exposures, as seen in the background part of the photo. The foreground shows glacially transported boulders scattered over the surface of till that mantles the hillside. The sandy till in this area is well suited for growing blueberries.

**Figure 4:** Exposure of till in a borrow pit in Penobscot, showing the stony texture and general lack of stratification that are typical of till deposits in the quadrangle.

**Figure 5:** Large boulder that was carried by glacial ice and left on the east shore of Wadsworth Cove in Castine.

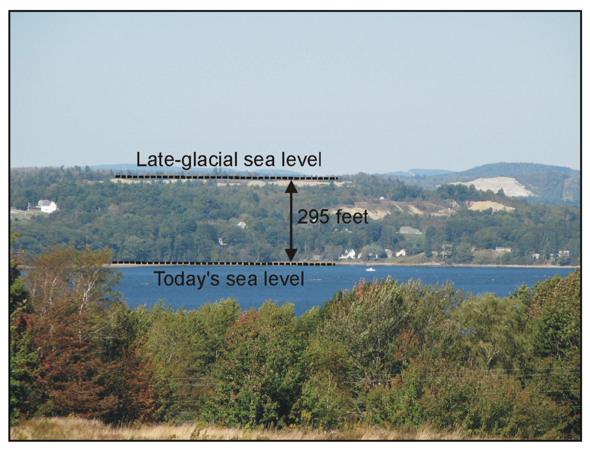


**Figure 6:** View looking northwest across Penobscot Bay to Mill Cove and vicinity in Stockton Springs (just north of the quadrangle). The flat hilltop in the distance is the upper surface of a delta that was built into the ocean at the edge of the glacier during recession of the ice sheet from coastal Maine. This delta shows that local relative sea level was nearly 300 feet higher than today in late-glacial time!

**Figure 7:** Stratified glacial-marine clay-silt on the shoreline of Penobscot Bay in Stockton Springs. This soft sediment is vulnerable to erosion resulting from combined wave attack and slumping.

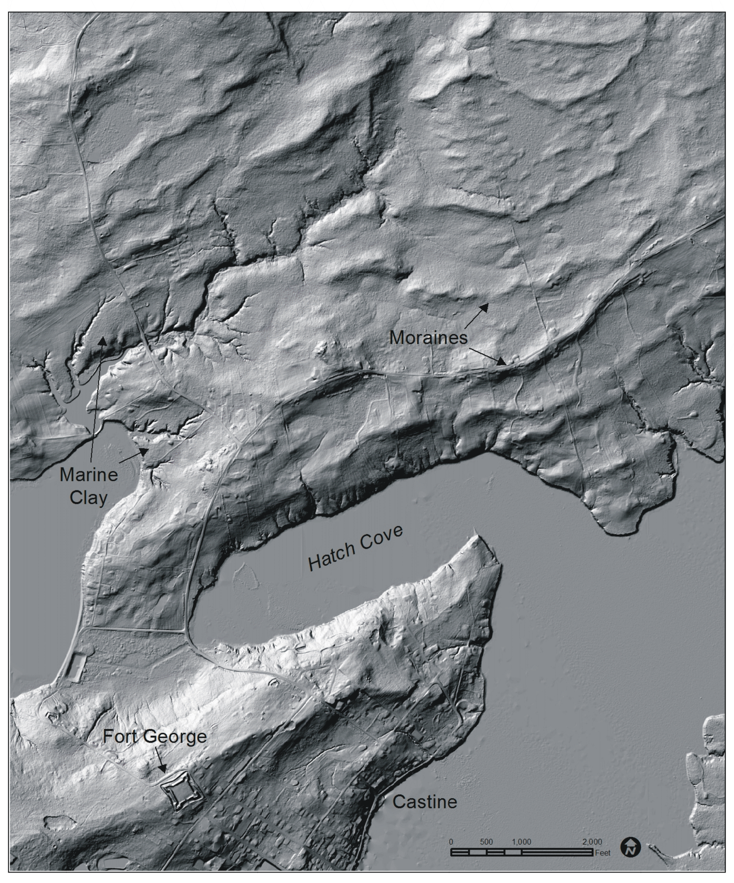


**Figure 8:** Shaded relief image derived from LiDAR image of the Hatch Cove area and part of Castine village. The east-west trending ridges are large moraines deposited at the margin of the last glacial ice as it receded. A low area of glacial-marine clay near the left margin of the image shows the branching gullies typical of the Presumpscot Formation. The moraine on which Fort George was built is anchored on bedrock and was extensively reworked by wave action as the sea receded, forming a veneer of marine nearshore sand and gravel.