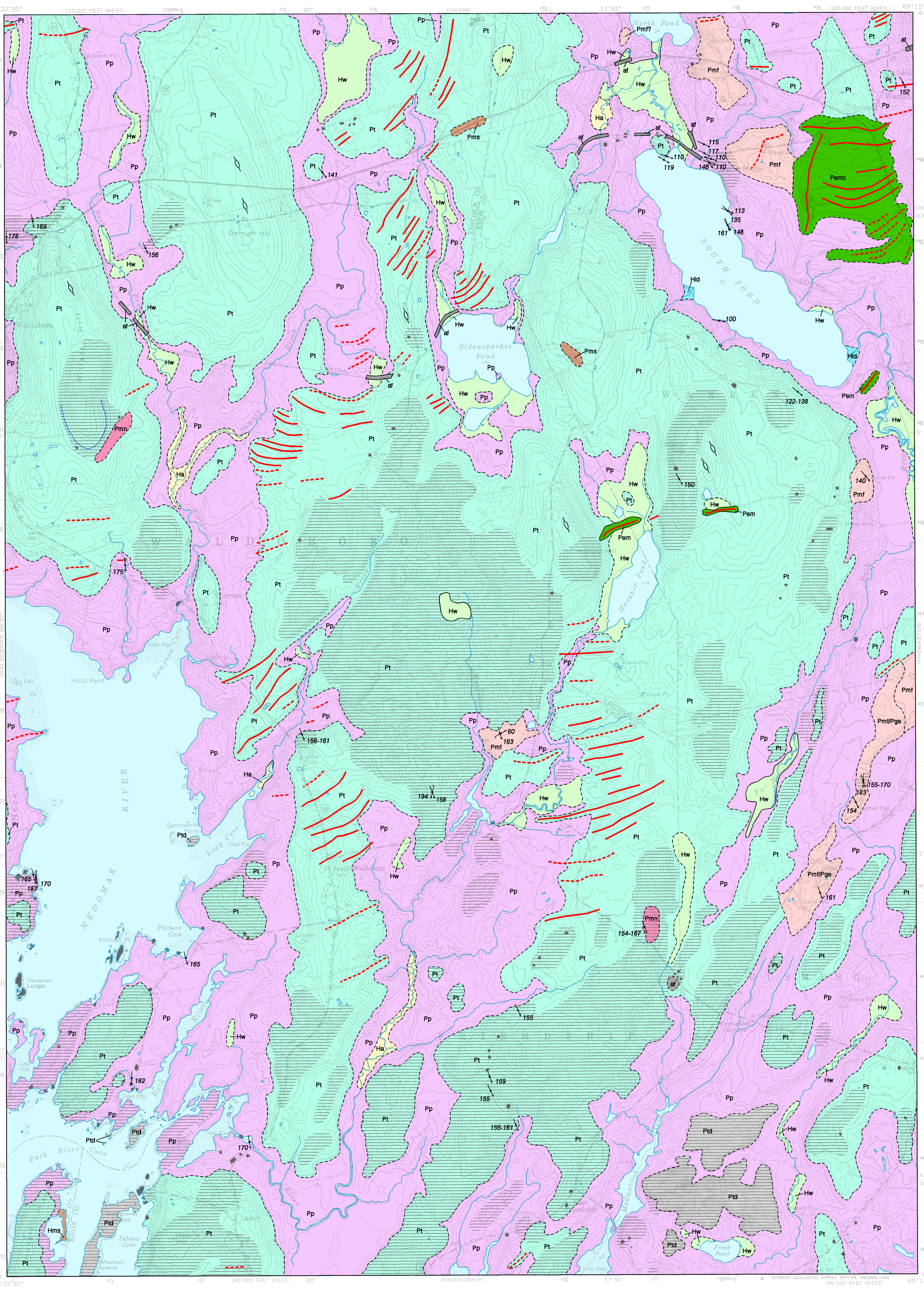
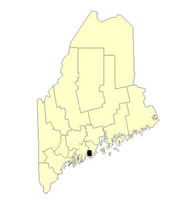
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic mapping of the Waldoboro East quadrangle was conducted by Woodrow B. Thompson during the 2010 and 2011 field seasons and modified using 2012 field data. Funding for this work was provided by the U.S. Geological Survey STATEMAP program and the Maine Geological Survey, Department of Conservation.



Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Waldoboro East 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.

Ha — **Stream alluvium** - Sand, gravel, and silt deposited on flood plains. May include organic wetland deposits or underlie some of the mapped wetland areas along streams.

Hw — **Wetland deposits** - Peat, muck, silt, and clay in poorly drained areas. Map unit may also include some alluvial sediments along stream valleys.

Hms — **Marine shoreline deposits** - Sand and gravel on modern ocean beach on east side of Hungry Island.

Hld — **Lacustrine delta deposits** - Sand, gravel, and silt deposited at the mouths of streams entering South Pond.

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 shorelines. The upper limit of marine submergence in the Waldoboro area was at an elevation of about 270 ft (82 m).

Pp — **Presumpscot Formation** - Glaciomarine silt, clay, and sand deposited on the late-glacial sea floor. This map unit 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 — **Glaciomarine fan** - Sand and gravel deposited in a submarine environment at the glacier margin during recession of the late Wisconsinan ice sheet.

Pmf/Pge — **Glaciomarine fan deposits (Pmf) overlying esker gravel (Pge)** - Area in which sandy to gravelly marine fans are inferred to be underlain by esker gravel deposited by subglacial meltwater streams. The esker gravel may have been removed in some places by pit operations, but was seen in a pit close to the Knox County line on the southern edge of Warren.

Pem — **End moraine** - Ridge formed along the margin of the late Wisconsinan glacial ice sheet during a brief pause in its retreat. Composed of till and/or sand and gravel.

Pemc — **End moraine complex** - A cluster of end moraines east of South Pond, in which numerous low moraine ridges composed of till and sand/gravel are locally overlain by clay-silt-sand of the Presumpscot Formation. The east-west moraines are bordered by a younger north-south moraine formed by the South Pond Readvance (Borns and others, 2004). This glacial readvance is further indicated by the ESE-trending striations in the South Pond area.

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. This map unit locally includes lenses of water-laid sand and gravel, 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 feet thick. Mapped from air photos and ground observations. Actual thin-drift areas probably are more extensive than shown. Dots mark locations of individual outcrops.

af — **Artificial fill** - Variable mixtures of earth, rock, and/or man-made materials used as fill for roads and railroads. 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.

Moraine ridge - Line shows inferred crest of moraine ridge deposited along the retreating margin of the most recent glacial ice sheet. These moraines are composed mostly of till but may also include sand and gravel. Dashed where identity is uncertain, including possible moraines mapped from air photos.

Former marine shoreline - Hachured line on Willett Hill in Waldoboro shows where an ocean beach existed in late-glacial time. The beach formed at the upper limit of marine submergence, at an elevation of about 270 ft (82 m) above present sea level. It is marked by a concentration of boulders and exposed bedrock along the 270-ft contour.

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 sets of striations are present and relative ages could be determined, the flagged arrow indicates the older flow direction.

Glacially streamlined hill - Symbol shows trend of long axis, which is parallel to former glacial ice-flow direction.

References:

Borns, H.W., Jr, Doner, L.A., Dorion, C.C., Jacobson, G.L., Jr., Kaplan, M.R., Kreutz, K.J., Lowell, T.V., Thompson, W.B., and Weddle, T.K., 2004, The deglaciation of Maine, U.S.A., in Ehlers, J., and Gibbard, P.L. (editors), Quaternary glaciations - extent and chronology, Part II: North America: Elsevier, Amsterdam, p. 89-109.

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 materials 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., and Locke, D. B., 2012, Surficial materials of the Waldoboro East quadrangle, Maine: Maine Geological Survey, Open-File Map 12-22.
2. Thompson, W. B., 1979, Surficial geology handbook for coastal Maine: Maine Geological Survey, 68 p. (out of print).
3. Thompson, W. B., and Borns, H. W., Jr., 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Waldoboro East Quadrangle, Maine

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Open-File No. 12-20
2012
This map supersedes Open-File Map 11-13.

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 Waldoboro East 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

Borns, H. W., Jr., Doner, L. A., Dorion, C. C., Jacobson, G. L., Jr., Kaplan, M. R., Kreutz, K. J., Lowell, T. V., Thompson, W. B., and Weddle, T. K., 2004, The deglaciation of Maine, U.S.A., *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations – Extent and Chronology, Part II: North America: Amsterdam, Elsevier, p. 89-109.

Davis, R. B., and Jacobson, G. L., Jr., 1985, Late-glacial and early Holocene landscapes in northern New England and adjacent areas of Canada: Quaternary Research, v. 23, p. 341-368.

Ridge, J. C., 2004, The Quaternary glaciation of western New England with correlations to surrounding areas, *in* Ehlers, J., and Gibbard, P. L., eds., Quaternary Glaciations – Extent and Chronology, Part II: North America: Amsterdam, Elsevier, p. 169-199.

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. Example of a "thin-drift area" on hill north of Finntown Road in South Waldoboro. A very thin cover of till has been partly removed, revealing bedrock just beneath the original ground surface. Glacial striations are preserved on some of the granite exposures seen here.

Figure 2. Glacially abraded bedrock outcrop located between Finntown Road and Waterman Brook in South Waldoboro. This unusual site shows an older set of glacial grooves (on wetted surface) indicating ice flow toward the ENE (060°). The red pencil points in the direction of a younger set trending SSE (163°).

Figure 3. Stony glacial till in Cushing. The till overlies sand and gravel (not seen in photo) and may have been deposited by a minor glacial readvance.

Figure 4. View along crest of moraine ridge extending east from Stahls Hill (between South Pond and Havener Pond in Warren). The ridge crest is at an elevation of about 260 ft, which is very close to the position of sea level in this area (~ 270 ft) when the moraine was deposited.

Figure 5. Cross-section view of east end of moraine ridge that extends from Stahls Hill in Warren. Gravel that occurs on the ridge surface may be part of the original moraine and/or the product of marine wave action.

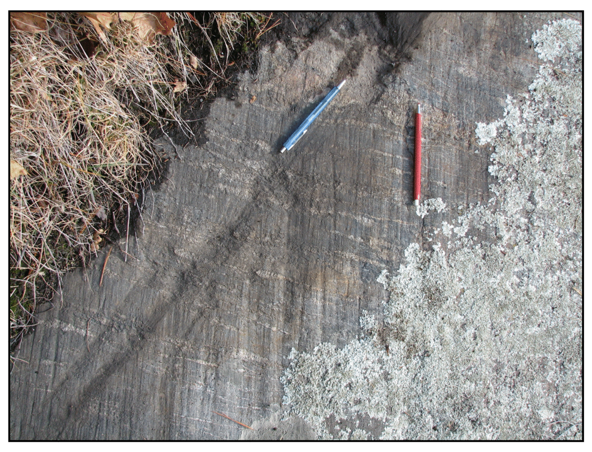

Figure 6. Intersecting sets of glacial striations and grooves on ledge just north of railroad track (and east of road junction) at Warren Station. Blue pen points in direction of earlier ice flow toward the SE (146°). Red pencil marks younger ice flow toward the ESE (110°) during the South Pond Readvance in late-glacial time. The readvance is likewise recorded by striations trending 100° on the south shore of the pond. It deposited the N-S moraine that truncates the earlier swarm of E-W moraines in the Warren area (Borns and others, 2004).

Figure 7. Many low areas in the quadrangle are underlain by clay, silt, and fine sand deposited on the sea floor during the period of marine submergence that immediately followed glacial retreat. These deposits are called the Presumpscot Formation (map unit Pp). The locality shown here is on the west shore of the Medomak River, just west of the public boat-launch site on Dutch Neck. The embedded pebble near the left side of the photo probably dropped to the ocean bottom from a floating iceberg.

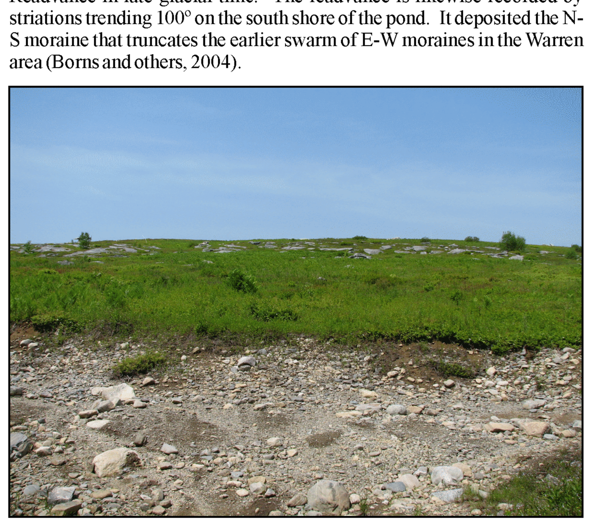

Figure 8. Marine nearshore gravel (map unit Pmn) on lower SE side of Willett Hill in Waldoboro. See also Figure 9.

Figure 9. This Google Earth image shows a prominent linear zone of exposed bedrock wrapping around the south end of Willett Hill. This feature resulted from surf action at the upper limit of late-glacial marine submergence, which reached elevations of about 270 ft in the Waldoboro area. Figure 8 shows nearshore gravel that formed as the glacial sediment cover was eroded from the ledges along the paleo shoreline.