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Surficial Geology of the Somersworth 7.5-minute Quadrangle, York County, Maine

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INTRODUCTION

The Somersworth 7.5-minute topographic quadrangle is located along the Maine-New Hampshire border in southwestern Maine. The principal town, Somersworth, is approximately 13 miles north of Kittery, Maine. The area lies within the Seaboard Lowland physiographic province, where altitudes range from sea level to 600 feet above sea level. The area is drained by the Salmon Falls River and its tributaries, which include the Little River. The Salmon Falls River reaches the coast at Kittery.

During the last (Wisconsinan) episode of glaciation, ice advanced from the northwest across the area to a terminal position on the continental shelf. Glacial erosion produced a distinct northwest-southeast topographic lineation. Streamlined erosional features are common, and several valleys paralleling the direction of ice movement display the effects of erosional deepening and steepening. Glacial deposition resulted in a general reduction of preglacial relief by preferential infilling of valleys. This effect is most pronounced in that portion of the area below the limit of late-glacial marine submergence.

Ice retreat, accompanied by marine submergence, progressed rapidly across the area in a general northwesterly direction. End moraines and composite deltas and fans were produced at or near the ice front during the period of retreat, and outline the pattern of ice withdrawal from the region.

Original mapping of the Somersworth quadrangle was conducted by Bloom (1960) at a reconnaissance level (1:62,500; 1:125,000). The area was remapped by Smith (1977) at a scale of 1:62,500 in the early stages of the Maine Geological Survey's reconnaissance mapping program. More detailed mapping of portions of the Somersworth quadrangle was undertaken in the several stages of the Survey's aquifer mapping program (D. W. Caldwell in Caswell, 1979; A. Tolman and others, 1983). The surficial geology of the Somersworth quadrangle was revised and updated for the present study during the 1989 field season (Smith, 1998, 1999). Koteff (1991) has mapped the small area in the southwest corner of the quadrangle that lies in New Hampshire.

Information bearing on the stratigraphy and glacial geologic history of this portion of Maine can be found in the following publications: Bloom, 1960, 1963; Smith, 1981, 1982, 1984, 1985, 1989. Publications by Thompson (1978, 1982), Stuiver and Borns (1975), and Thompson and Borns (1985) provide helpful general references to the glacial geology of the entire coastal zone.

GLACIAL AND POSTGLACIAL PROCESSES

The general succession of glacial and postglacial deposits in the coastal lowland of York County is presented in Tables 1 and 2 and Figure 1. All glacial deposits in the area are ascribed to the Late Wisconsinan glacial episode. Deposits exposed above the marine limit record both glacial advance and retreat, while most sediments exposed below the marine limit are related to deglaciation and late-glacial marine submergence.

Glacial Till (Pt)

Glacial till occurs throughout the mapped area, both above and below the marine limit. Thickness of the till is variable, as is its composition. Below the marine limit, till occurs in a variety of genetic types. Lodgement till, flow till, and melt-out till comprise the cores of many small moraines. Both above and below the marine limit, lodgement till forms a blanket deposit over topographic highs and is inferred to underlie younger deposits in topographic lows. This till is typically a bouldery, gray, compact material, with a sand-silt-clay matrix. Locally, thicker accumulations of lodgement till have been streamlined to form drumlins.

TABLE 1. TIME/SPACE RELATIONSHIPS OF GLACIAL MATERIALS IN YORK COUNTY*

	Glacial	Glacial Fluvial		Glacial Marine	Fluvial	Wetland	Marine
HOLOCENE							Hms
							Hwsm
					Ha	**Hws**	
					Hst	**Hwfm**	
						Hwh	
PLEISTOCENE / LATE WISCONSINAN				Pms			Pmn
				Pmrs			
		Pgo	**Pmd**	**Pp**			
		Pgi	**Pmdi**				
		Pge		**Pm**			
			Pfemc				
			Pemc				
			Pem				
	Pt						
	Ptd						

* Units that occur in the Somersworth quadrangle are shown in boldface type.

Ice-Contact Stratified Drift and End Moraines (Pgi, Pge, Pem, Pemc)

Ice-contact stratified drift occurs in a variety of forms throughout the Somersworth quadrangle. Northern portions of the quadrangle contain extensive deposits of ice-contact gravels related to esker sedimentation and ice stagnation in the uplands above the marine limit. In the southern portions of the quadrangle, generally below the marine limit, ice-contact sediments occur in association with end moraine complexes and buried eskers.

End moraines and end moraine complexes in the area of marine submergence contain sand and gravel that both underlies and intertongues with the Presumpscot Formation. This material is subaqueous outwash (Smith, 1982, 1985, 1989; Thompson, 1982; Retelle and Bither, 1989). In many exposures, it displays a variety of distinctly fluvial primary structures. Elsewhere, it has the appearance of subaqueous debris flow deposits (Figure 2). In many cases, the sediments have been severely deformed by thrusting and ice shove, and are complexly interstratified with till and marine sand, silt, and clay.

Presumpscot Formation (Pp, Pm) and Marine Regressive Sand Deposits (Pmrs)

Glacial marine deposits of the Presumpscot Formation occur as a discontinuous cover of sediment up to 50 m thick throughout the area of late-glacial marine submergence. The general distribution of the marine sediments was originally mapped by Goldthwait (1949), and the sediments were described in detail and given formational status by Bloom (1960). The marine clay and silt (Pp) is the type Presumpscot Formation described by Bloom. It underlies, in gradational contact, the sandy facies (Pmrs) of the marine sediments, which is considered to be simply a regressive counterpart of the Presumpscot Formation.

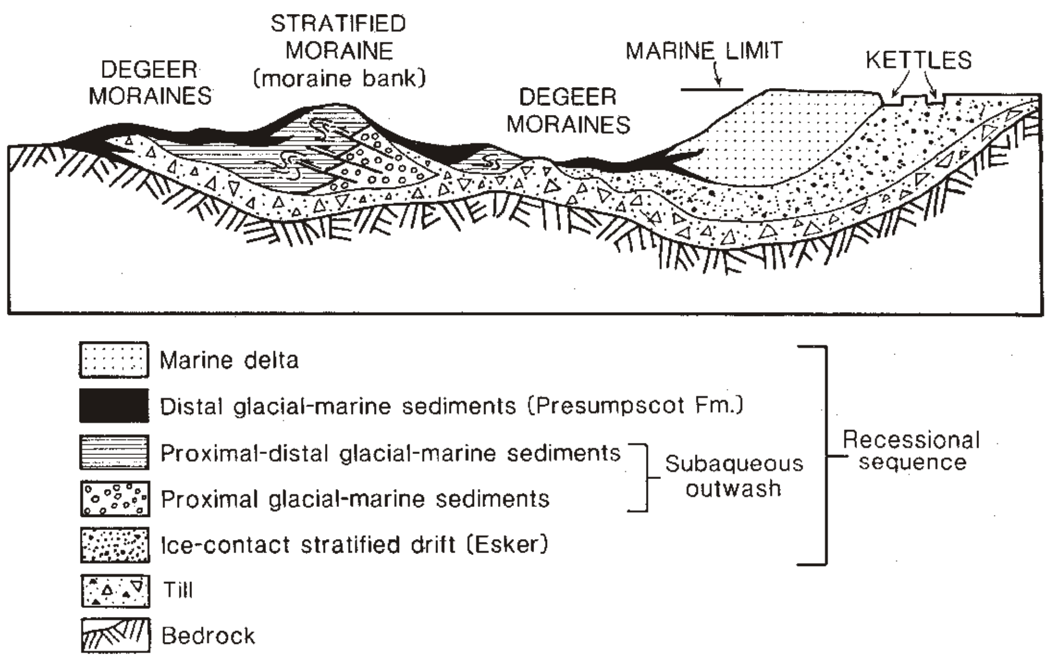

Figure 1. Generalized stratigraphy of Late Wisconsinan glacial deposits of coastal Maine (from Smith, 1985).

TABLE 2. DESCRIPTION OF MAP UNITS*

SYMBOL	UNIT	DESCRIPTION
Ha	**Stream alluvium**	Gray to brown fine sand and silt with some gravel. Comprises floodplains along present streams and rivers. Extent of alluvium approximates areas of potential flooding.
Hst	Stream terrace deposits	Sand and gravel on terraces cut by postglacial streams.
Hws	**Wetland, swamp**	Muck, peat, silt, and sand. Poorly drained areas, often with standing water.
Hwfm	**Wetland, freshwater marsh**	Poorly drained freshwater grassland.
Hwsm	Wetland, saltmarsh	Muck, peat, silt, and sand. Coastal settings subject to tidal fluctuation.
Hmsh	Marine shoreline deposit, beach	Sand, some gravel and minor silt. Coastal settings of active beach environments.
Pmrs	**Regressive marine sand deposits**	Massive to stratified and cross-stratified, well sorted brown to gray-brown sand. May have gradational basal contact with Pp. Thickness between 1 and 5 m. Deposited during regressive phase of marine submergence.
Pp	**Presumpscot Formation**	Massive to laminated gray and blue-gray (weathering to brown) silt and silty clay. Locally may contain boulders, sand, gravel. Occurs as blanket deposit over bedrock and older glacial sediments. Variable thickness from less than 1 m to more than 50 m. Deposited during period of late-glacial marine submergence.
Pms	Marine shoreline deposit	Predominantly sand with minor gravel. Beach deposits formed during period of stillstand in regressive phase of marine submergence. Thickness variable from less than 3 m in beach ridges to more than 10 m in aprons around eroded drumlins.
Pm	Marine deposits	Pp and/or Pmrs deposits mapped in areas of poor access or poor exposure, or where both units occur as areas too small to be mapped separately. Thickness variable within range described for Pp and Pmrs.
Pgo	**Outwash**	Sand, gravel, and minor silt deposited by glacial streams in a proglacial (away from ice) setting. Generally confined to major river valleys. Sometimes terraced. Average thickness probably between 5 and 10 m.
Pmd **Pmdi**	**Marine delta**	Coarse sand and gravel grading to sand and silt. Flat to gently sloping constructional surface formed by glacial streams discharging into late-glacial sea. Heads of ice-contact deltas (Pmdi) are commonly kettled and mark ice frontal positions. Sediments in distal portions of deltas commonly grade into glacial marine sediments (Pp, Pmrs). Variable thickness from more than 30 m at delta head to less than 1 m at delta toe.
Pgi	**Ice-contact deposits** (undifferentiated)	Coarse gravel and sand. Primarily kettled glacial stream deposits in the immediate vicinity of eskers (Pge). Average thickness probably between 10 and 15 m.
Pge	**Esker**	Coarse gravel and sand comprising distinct linear ridges, mostly in major valleys. Generally surrounded by Pgi deposits, and terminating in ice-contact deltas. May be more than 10 m thick.
Pfemc	Fan-end moraine complex	Composite designation incorporating elements of end moraines and subaqueous fans. Coarse to fine sand and gravel extending from fan head to fan toe. This material overlies sediments of end moraines and end moraine complexes. Refer to Figure 2.
Pem	**End moraine**	Coarse gravel and sand; locally includes till and silt. Generally occurs in areas of glacial marine sediments (Pp, Pmrs), and is complexly interstratified with them. Formed at or near the ice front during retreat of marine-based glacier. Sediments commonly display significant deformation. Typically 5 to 10 m thick.
Pemc	**End moraine complex**	Coarse gravel, sand, till, and silt; commonly over shallow bedrock. Mapped in areas of closely spaced small (DeGeer) end moraines. Formed at or near ice front during retreat of marine-based glacier. Sediments commonly display significant deformation. Generally less than 5 m in thickness.
Pmn	Marine nearshore deposits	Areas of till that have been reworked by the sea during regressive phase of marine submergence. Till has had finer constituents (silt and sand) removed and redeposited as thin veneer over till. Bedrock commonly at shallow depth. Average thickness probably less than 3 m. Locally, this unit may include marine clay and sand, as well as isolated boulders. Originally mapped as Pwts (washed till and sand).
Pt	**Till**	Gray to gray-brown poorly sorted mixture of silt, sand, pebbles, cobbles, and boulders. Forms a blanket deposit over bedrock, and is inferred to underlie younger sediments where not exposed at surface. Thin over topographic highs; thickens in topographic lows. May occur in and over end moraines (Pem, Pemc). Averages 3 to 5 m in thickness.
Ptd	Till, drumlin	Same materials as till. Mapped in areas of streamlined hills (drumlins) where till may be up to 30 m thick.
rk	Bedrock	Rock units not distinguished. Individual outcrops not shown in large areas of poor access. Ruled pattern indicates areas where surficial materials are thin (less than 1 to 2 m) and bedrock exposures are common. Areas of bedrock exposure (solid color) are mapped in part from aerial photographs.

* These units are regionally distributed across York and Cumberland Counties. Only the ones in boldface type occur in the Somersworth quadrangle.

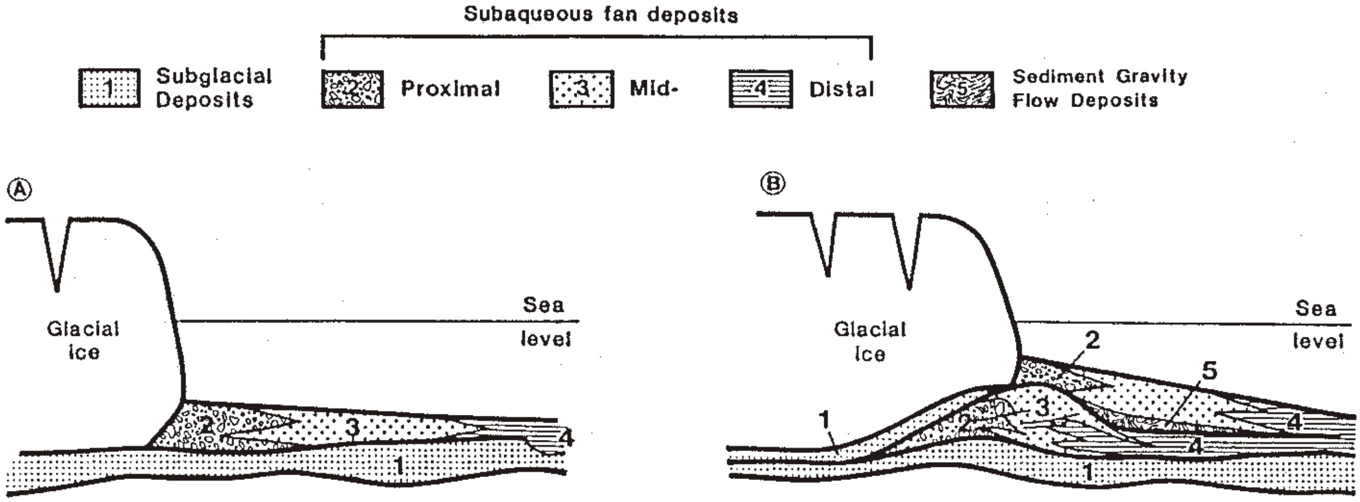

Figure 2. Stratigraphic relationships of subaqueous fan association (a) and subaqueous end moraine association (b). The simple stratigraphic situation of the subaqueous fan association is complicated during minor glacial readvance by glacial-tectonic deformation and thickening of the sedimentary package to produce an end moraine (from Smith, 1989).

The Presumpscot Formation bears a complex stratigraphic relationship to other glacial sediments below the marine limit. It generally overlies till with sharp contact. Subaqueous outwash underlies and intertongues with the Presumpscot Formation.

Glacial Outwash (Pgo)

Glacial outwash consists of sand and gravel deposits that occur as valley fills adjacent to major stream valleys. These sediments were deposited by glacial meltwater streams in a proglacial setting as ice retreated and sea level fell. Technically speaking, the distal portions of ice-contact deltas can be considered to be outwash deposits. However, for the sake of clarity in the presentation of map units, the deltas were considered to be simple depositional entities formed in contact with the retreating ice margin.

Deposits of Wetlands and Modern Streams (Ha, Hwfm, Hwhp, Hws)

Deposits of wetlands and modern streams have been mapped throughout the Somersworth quadrangle. They are most significant in areas of relatively thin sediment cover and in areas adjacent to modern streams. They comprise swamps (Hws), marshes (Hwfm), heaths (Hwhp), and local occurrences of floodplain alluvium (Ha).

GLACIAL AND POSTGLACIAL HISTORY

All glacial deposits found in the Somersworth area have been ascribed to the last (Late Wisconsinan) glacial episode to affect coastal Maine. The oldest deposits thus far recognized in the coastal zone are those exposed in coastal cliffs at and near Great Hill (Wells quadrangle), east of Rochester-Somersworth (Smith, 1985). The deposits at Great Hill are thought to record the advance and retreat of the last ice sheet to and from its terminal position on the continental shelf east of the present coastline. In all likelihood, deposits of till in the Somersworth area record the same event, and stratified sediments record retreat of this last ice from the coastal zone in a marine setting.

The orientations of drumlins and other streamlined forms, as well as the orientations of glacial striations, indicate that the last ice to cover the area advanced from the northwest. Local divergence from this general trend resulted from topographic control on the pattern of ice flow.

Withdrawal of Late Wisconsinan ice from its terminal position was underway between 17,000 and 15,000 years ago, and the glacier margin had retreated across the Gulf of Maine to a position roughly parallel to, but some distance offshore of, the present coastline by 14,000 years ago (Smith, 1985). Dates on shells collected from the Wells-Kennebunk area indicate that ice remained in the vicinity of the southwestern Maine coast until 13,200 years ago.

Two indirect effects of glaciation had a very strong bearing on the character of ice retreat and the deposition of glacial sediments in this portion of the coastal zone. First, the great weight of ice depressed the Earth's crust beneath the glacier significantly below its present level throughout the region. Secondly, as the glacier expanded, water was trapped on land as ice, and sea level, as a result, was lowered by several hundred feet. As ice began to melt and retreat, water was returned to the ocean and sea level rose immediately. At the same time, the crust began slowly to rebound to its original level. The interaction of these two effects resulted in submergence of the entire Maine coastal zone for a period of several hundred years following retreat of ice. Furthermore, the glacier was grounded in the sea during its re-

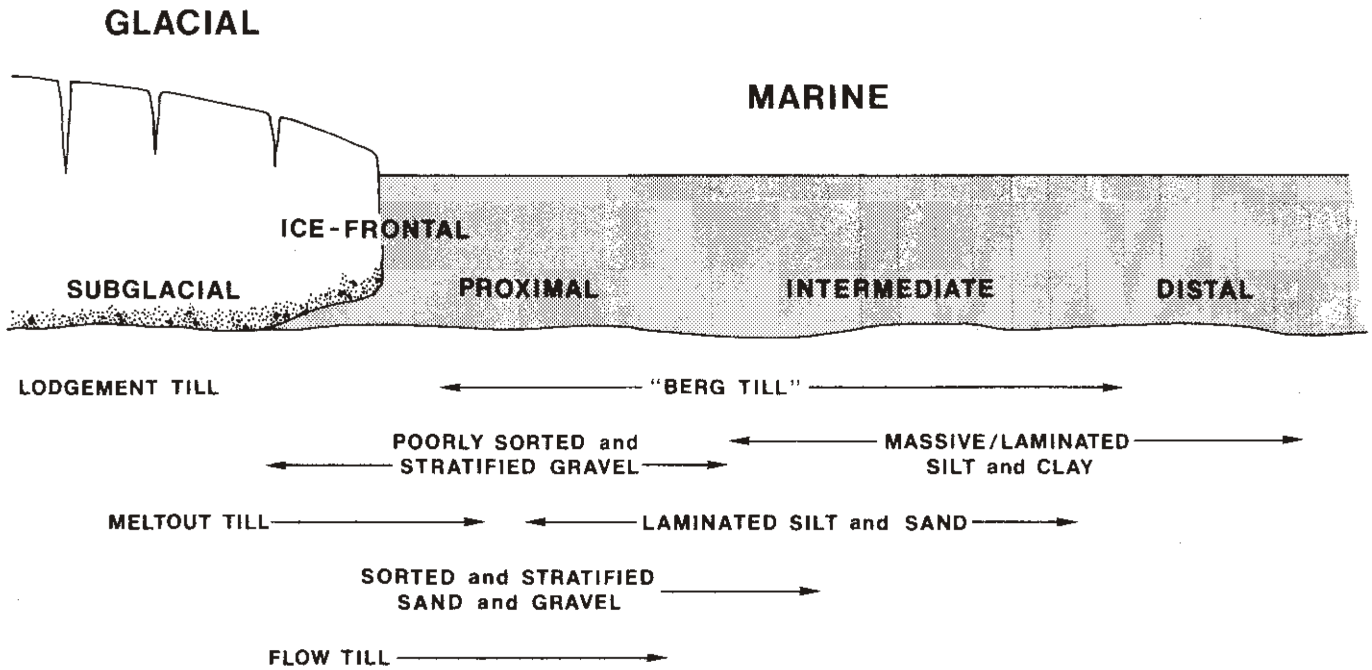

Figure 3. Glacial marine facies associations for the Maine coastal zone (from Smith, 1984).

treat, so that a complex assemblage of glacial marine sediments was deposited over the area below the marine limit (Figure 3).

As ice began to retreat in a general northwesterly direction across the Somersworth area, coarse clastic sediments (till and ice-contact stratified drift) accumulated adjacent to the ice front, while fine sediment (silt and clay of the Presumpscot Formation) was deposited further away from the ice (Figure 3). Continued ice retreat resulted in the overlap of distal (fine-grained) sediments on earlier proximal (coarse) sediments.

During the period of ice retreat, at least while ice was marine-based, it remained active and continued to advance periodically over short distances. These advances resulted in deformation of previously deposited sediments (Figure 2) and construction of minor (DeGeer) moraine ridges. During periods of extended stillstand, sediments accumulated at the ice front (or grounding line) to form larger end moraines, subaqueous fans, and partial or complete deltas. Numerous end moraines (Pem) and end moraine complexes (clusters of moraines - Pemc) formed along successive ice-margin positions in the southeastern part of the quadrangle, where there was marine submergence to an elevation of about 200 feet.

Esker deposits can be traced for a considerable distance north into the Rochester quadrangle, and may extend southeastward into the Somersworth quadrangle across Long Swamp Road, and then into the Little River valley in the vicinity of Stackpole Bridge. In all likelihood, ice-contact sediments related to this esker system underlie, or are interbedded with, the extensive deltaic outwash (Pgo) apron that fills the east side of the Salmon Falls River valley between Berwick and South Lebanon (Rochester quadrangle). The same esker may likewise have contributed sediment to the marine deltas in the Somersworth quadrangle that extend from Thompson Hill and Matthews Hill to Five Corners. A clearly defined esker (perhaps part of the same system) extends southeastward from the vicinity of Thompson Hill, where it is associated with end moraine complexes (Pemc), to the area north of Knights Pond (SE corner of Somersworth quadrangle).

Ice-contact sediments (Pgi) within the mid-reaches of the Little River valley (northwest and central portions of Somers-s-worth quadrangle) are not associated with formation of the nearby esker. They seem, instead, to be related to ice-stagnation during final withdrawal of ice from the area. Large and small kettles are common, and overflow channels extend to the south and southeast from the southern end of these deposits (around Diamond Hill), and to the east (north of Beech Ridge). Water and sediment from these overflow channels contributed significantly to the construction of the deltaic deposits that extend from Thompson Hill to Five Corners.

Ice-contact sediments are also exposed in several end moraine complexes, predominantly in the southern and eastern portions of the Somersworth quadrangle. The genesis and significance of these features has been described in other reports (Gorham and North Berwick quadrangle reports). One of the more noteworthy deposits is a small ice-contact glacial-marine delta (Pmdi) located on the south side of Route 4. Although much of this delta has been removed by gravel pit operations, a formerly exposed contact between topset and foreset beds indicated that the sea reached an elevation of 200 feet in the Berwick area (Thompson and others, 1989).

Well-sorted proglacial marine deltas (Pmd) may well comprise the most important group of sediments in the Somersworth area. An extensive outwash delta has been mapped in the Somersworth quadrangle between Thompson Hill (and Matthews Hill) and Five Corners. These deposits consist of relatively clean, well stratified fluvial sediments of relatively coarse size (sand and gravel). They are good potential ground water aquifers and a source of construction aggregate. They are clearly to be avoided as sites for waste disposal.

Most of the sediment involved in formation of this delta complex was provided by glacial streams that carried water and sediment from melting ice in the northern part of the Somersworth quadrangle. The general configuration of this deposit suggests that it formed in a littoral setting as a highly constructive delta in the late-glacial sea. At its inland limit, the headward part of the delta complex has a present surface elevation of 240-260 feet asl.

The ice-contact deposits in the northern part of the quadrangle were deposited beneath or alongside ice in a terrestrial setting (above the marine limit). Outwash and deltaic deposits were deposited in settings that ranged from ice marginal to distal proglacial, and are, thus, in part terrestrial and in part subaqueous. Commonly, the outwash deposits mapped here grade southward and eastward to the sandy regressive marine deposits (Pmrs).

As ice withdrew northwestward across the Somersworth area, isostatic rebound began to elevate the land, and sea level began to fall. With continued lowering of sea level, materials deposited during earlier stages of glaciation and deglaciation passed through the wave zone, were eroded, and shed sandy sediment (Pmrs) over the silt and clay deposited when sea level was higher (Pp). Short-term pauses in the lowering of sea level allowed for incision of streams into older sediments, producing erosional scarps and thin accumulations of beach sediments. Records of some of these events can be documented between the position of maximum marine submergence (200-220 feet asl) and the position of present sea level.

Following withdrawal of ice from the coastal zone and the completion of isostatic rebound, sea level became established at its present position. Streams were graded to this level and began to construct floodplains (Ha). In the beach zone, marine processes constructed sand beaches and produced saltmarsh deposits within the zone of tidal fluctuation. Swamps (Hws) and other types of wetlands developed in areas of elevated water tables and poor drainage.

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APPENDIX: ADDITIONAL SITE INFORMATION FOR MATERIALS MAP

Site No.	Description
13	Evidence of collapse deformation. Current bedding indicates flow S20-25E. Probably related to SE-trending esker that runs from Little River to west of Diamond Hill. Possible source in meltwater deposits(?) to NW.
23	Striations trend S35E.
24	Striations trend S45E.
42	Possible wash zone related to beach (marine limit?).
53	DeGeer moraines.
75,82	Shallow exposures and surface morphology between sites 82 and 75 on Pine Hill Road suggest occurrence of DeGeer moraines over till (juxtaposed till and sand and gravel with distinct constructional morphology).
84	DeGeer moraine.
94	Striations trend S10-15E.
100	Probable moraine.
109,111	Exposures between sites 109 and 111 suggest either moraine complex or washed till (juxtaposition of till and sand and gravel).
118	Erosional scarp below (south of) road.
128	Several S-SE directed drainage channels cut into till.
130	Several S-SE directed drainage channels along Schoolhouse Road.
131	E-NE directed drainage channels.
137	Surface morphology suggests streamlining (drumlins) of relatively thick till.
143	Topset/foreset contact at 220+ ft. Topsets dip S20-30W.
147	May be wash zone over till.
151	Morphology suggests DeGeer moraines.
152	DeGeer moraines.
153	DeGeer moraines.
162	Possible esker (or moraine) segment.
169	Possible DeGeer moraines.
179	DeGeer moraines.
180	DeGeer moraines.
198	Surface morphology indicates DeGeer moraines.
199	DeGeer moraines.
200	DeGeer moraines.
201	DeGeer moraines.
206	DeGeer moraines.
208	DeGeer moraines.
210	Ice-contact deformation. Appears to be complex of DeGeer moraines developed over esker core and covered by marine sediments.
211	Ice-contact deformation. Appears to be complex of DeGeer moraines developed over esker core and covered by marine sediments.
212	Ice-contact deformation. Appears to be complex of DeGeer moraines developed over esker core and covered by marine sediments.
246	Striations trend S30-40E.
257	DeGeer moraines.
258	DeGeer moraines.
283	DeGeer moraines.
293	DeGeer moraines.
295	DeGeer moraines.
298	DeGeer moraines.
299	DeGeer moraines.
301	DeGeer moraines.