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Surficial Geology of the Naples 7.5-minute Quadrangle, Cumberland County, Maine

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INTRODUCTION

The Naples 7.5' quadrangle has an area of about 133 km^2 (52 mi^2). It is located in southwestern Maine, within the Seaboard Lowland physiographic province, about 32 km (20 mi) northwest of Portland. Altitudes range from 89 m (267 ft), which is the level of Sebago Lake, to more than 260 m (780 ft) on Barton Hill near the northeastern corner of the quadrangle. Most of the map area is underlain by granitic bedrock of the Sebago pluton. The Sebago pluton is light-gray to pink, medium-grained, non- to slightly foliated, biotite-muscovite granite. The granite is intruded in places by Mesozoic pegmatite dikes and basalt or diabase dikes. In a few places in the quadrangle, there are exposures of roof pendants of metasedimentary rocks that the Sebago pluton intruded during the Mississippian Period about 354 million years ago (Hussey, 1985).

Ridges in the Naples quadrangle commonly were shaped by glacial ice flowing toward the south-southeast and have been elongated in that direction. The topography of the study area is also controlled partly by jointing in the Sebago pluton. For example, the northwestern part of Sebago Lake is up to 90 m (300 ft) deep. The great depth of this basin probably has resulted from glacial plucking of joint blocks in the Sebago granite.

The major stream drainage in the Naples quadrangle is southward via the Crooked and Songo Rivers into Sebago Lake. These rivers merge at Songo Lock about 2.2 km (1.4 mi) north of the lake. The Songo River continues from the lock to the lake, into which it has built a substantial Holocene delta that is normally submerged because a dam has raised the lake level.

The valley of the Songo River, which includes Long Lake and Brandy Pond, is partly filled with sediments deposited by glacial meltwater, predominantly on the south and west sides. The valley of the Crooked River is completely filled with glacial meltwater deposits. These sediments form a "valley train" outwash system that extends from Sebago Lake up the Crooked River valley as far as 32 km (20 mi) north, almost to the modern-day Androscoggin River near Bethel (Figure 1). Caldwell and others (1985, p. 52) point out that deposits of glacial streams in Maine form a dendritic pattern that may reflect preglacial drainage (Figure 2). Thus the preglacial Androscoggin River may have flowed from Bethel southward down the Crooked River valley into the Sebago Lake area; and the late-glacial Androscoggin River, laden with meltwater sediments, probably followed the Crooked River valley for some time during deglaciation before being diverted to its modern course (Figures 1 and 2).

It is also notable that deep valleys east and west of the Crooked River valley contain sparse glacial outwash deposits, particularly Pleasant Lake and Parker Pond on the east and Long Lake on the west (Figure 1). This subject invites further investigation beyond the scope of this report.

The present investigation was carried out as part of a cooperative geologic mapping project funded by the Maine Geological Survey and the U.S. Geological Survey. Two maps are associated with this report. The *geologic map* (Hildreth, 1997) shows the distribution of the sedimentary units and discusses their age, composition, and origin. It also includes information relating to the geologic history of the quadrangle, such as glacial striation azimuths and radiocarbon dates on fossil organic remains. The geologic map provides the basis for the discussion of glacial and postglacial history presented here. The *materials map* (Hildreth, 1998) shows specific site data used to help compile the geologic map. These data include observations from gravel pits, shovel and auger holes, construction sites, and test borings.

PREVIOUS WORK

Early work on the surficial geology in this part of Maine was done generally at a reconnaissance level and at a smaller scale (Bloom, 1960, 1963; Thompson and Smith, 1977; Thompson and Borns, 1985a,b). Bloom (1959) produced a geologic

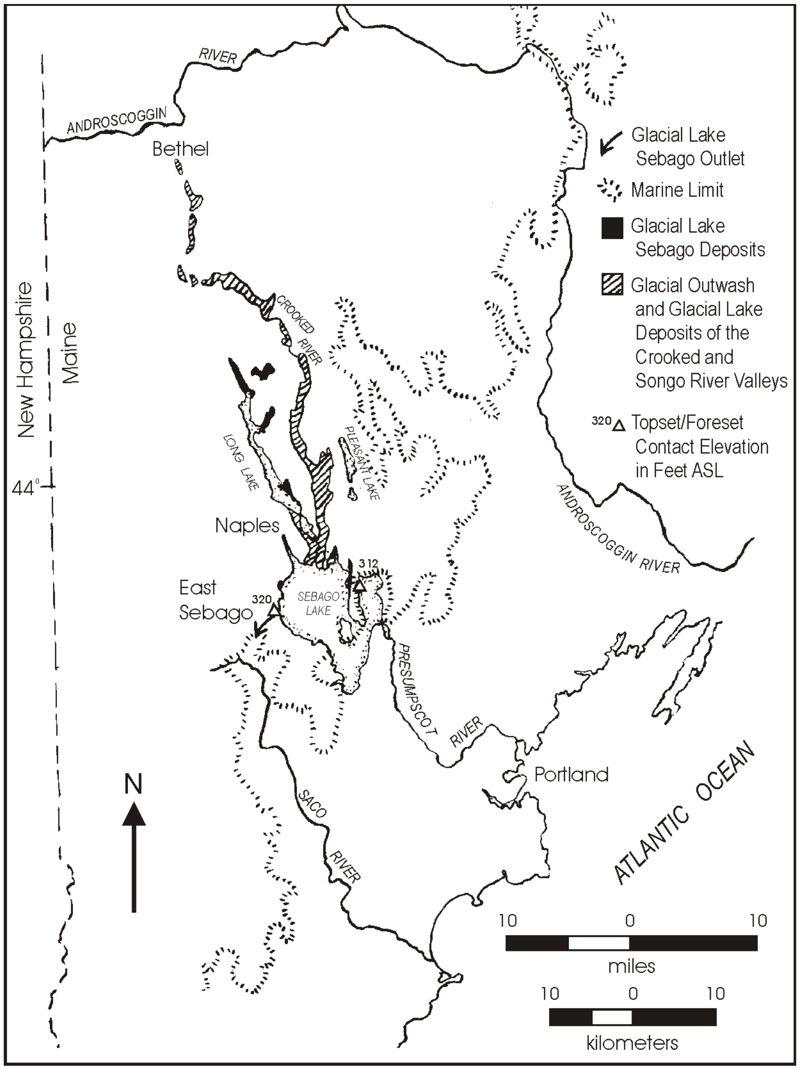

Figure 1. Map of western Maine showing features discussed in the text. Modified from the Surficial Geologic Map of Maine (Thompson and Borns, 1985a).

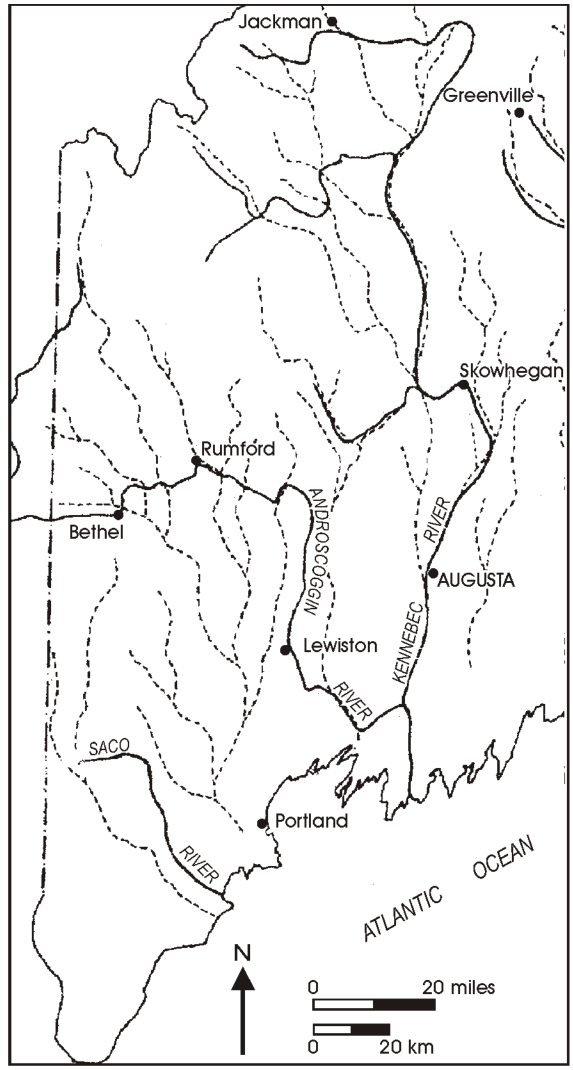

Figure 2. Map of a portion of Maine showing the contrast between the drainage pattern of modern rivers (solid lines) and the patern of glacial streams inferred from meltwater deposits (dashed lines). Modified from Caldwell and others (1985, Figure 8).

map for his report on the geology of Sebago Lake State Park, in which he described many of the features and landforms in detail. Significant sand and gravel aquifers were mapped by Williams and Lanctot (1987). Glacial features in the Naples area, such as marine deltas and lacustrine rhythmites were investigated and discussed in recent years by many workers (Thompson and others, 1989; Thompson and others, 1995a,b). The soil survey of Cumberland County greatly facilitated fieldwork (Hedstrom, 1974).

GLACIAL HISTORY

Southwestern Maine probably experienced several episodes of glaciation during the Pleistocene Ice Age, but virtually all evidence of previous glaciations in the Naples area was obliterated during the last (late Wisconsinan) episode, when the Laurentide ice sheet advanced from the northwest to a terminal position on the continental shelf.

Evidence of glacial erosion within this area is noticeable mainly as glacial striations on freshly exposed bedrock surfaces. Ramp-and-pluck topography on bedrock knobs, including a few roche moutonnées associated with striations, definitely records southeastward movement of the ice. It should be noted that glacial striations weather rapidly and survive only a very short time (generally only a few decades) after exposure to surface elements in the Maine climate. Those seen along the shore of Sebago Lake are on bedrock surfaces recently stripped of overlying sediments by wave action (probably due to the lake level having been artificially raised by the modern dam). Most other striations were found on recently excavated bedrock surfaces.

Generally, the striations indicate a south-southeast direction of ice flow; some variations can be attributed to local deflection around irregularities of the bedrock topography. At one locality on Route 302 northwest of Thomas Pond, two sets of intersecting striations trend 158-167^o and 133-137^o, the latter being the earlier set. This relationship is consistent with intersecting sets found elsewhere in southwestern Maine (Hildreth, 1999a-d). Some previous workers in the Kennebunk area have interpreted similar features as evidence of a glacial readvance, but this idea has been challenged (Smith, 1982).

After reaching its terminal position on the continental shelf, the late Wisconsinan ice sheet began to recede between 15,000 and 17,000 years ago. Shells collected from glaciomarine sediments deformed by ice shove in the Freeport area (east of Naples) have a radiocarbon age of 14,045 yr B.P. (Weddle and others, 1993). The ice sheet terminus is inferred to have reached the Naples quadrangle by about the same time.

According to Smith (1999a,b), "Two indirect effects of glaciation had a very strong bearing on the character of ice retreat and the deposition of the glacial sediments in this portion of the coastal zone. First, the great weight of the Laurentide continental ice sheet depressed the crust beneath the glacier significantly below its present level throughout the region. Secondly, as glaciers expanded worldwide, water was trapped on land as ice, causing sea level to be lowered by several hundred feet. Later, as the 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 effects resulted in submergence of the entire Maine coastal zone for a period of several hundred years following the retreat of the ice."

The Naples area lies at or near the limit of maximum marine submergence in this part of Maine (Figure 1). The transgressive sea level surface has been mapped by measuring the elevations of the topset-foreset contact in deltas deposited by glacial meltwater in the late Wisconsinan sea (Thompson and others, 1989). Deposits on Raymond Neck (Pmdrn) have been interpreted to be a marine delta in which a possible topset-foreset contact has been measured at 95 m (312 ft) above sea level (Thompson and others, 1989). Other deltaic deposits at East Sebago (Figure 1) on the west shore of Sebago Lake, about 13 km (8 mi) south-southwest of Naples, have been interpreted to be either lacustrine or marine and have a topset-foreset contact at 99 m (326 ft) above sea level (Gosse and Thompson, 1999a,b).

No glaciomarine silt and clay (Presumpscot Formation) deposits were found in the Naples quadrangle. In valleys where these deposits might be expected, rhythmic-bedded silt and clay characteristic of lacustrine environments was found. Thus, the late-glacial sea does not appear to have entered the area north of Sebago Lake. "The northwestern part of Sebago Lake actually extends below sea level, with a maximum water depth that exceeds 100 m (328 ft). An ice blockage would have been required in this part of the lake to exclude the sea from the Crooked River valley, because marine deltas and clay deposits do occur along the eastern and southern margins of Sebago Lake" (Thompson and Borns, 1985b).

The present author accepts the interpretation of an ice block in Sebago Lake and proposes that much of the glacial meltwater within the Naples quadrangle (possibly even in the Raymond Neck area) drained around this ice and through a col at 95-98 m (310-320 ft) above sea level. This proposed spillway is located southwest of East Sebago (Figure 1), and about 17 km (10 miles) southwest of Naples. Alternatively, meltwater drainage may have been dammed directly by the ice block in the lake. The morphology in the valley headed by the East Sebago col consists of a southwest-trending bouldery ridge (Thompson and others, 1995a, Stop 6) that could be a remnant of till or other material left by the erosional force of a massive volume of meltwater spilling out of the late-glacial lake in the Naples area, here called *glacial Lake Sebago*. Meltwater draining through this spillway entered the Saco River valley to the southwest, which was presumably free of ice at the time.

How long glacial Lake Sebago existed is uncertain. One section of rhythmic silt-clay deposits near Songo Lock (Site 8 on the materials map) contains more than 130 rhythmites(varves) which indicate a lake of at least 130 years' duration. Glacial Lake Sebago may have existed for some time after the ice block melted out of the lake basin, if it was dammed at a higher level than today by the glaciomarine ice-contact delta at the south end of the modern lake.

It is not certain when the East Sebago col was abandoned as a spillway, but when it was, one or two temporary spillways through surficial deposits at the south end of the lake were progressively cut down over time. This lowering of base level in the Sebago basin resulted in a series of stream terraces being cut into the glacial outwash in the Crooked and Songo River valleys to the north. Lake drainage via this southern route was subsequently pirated, however, because the modern spillway for Sebago Lake is through till deposits on the east shore. This outlet is near White Bridge in the North Windham quadrangle, where the lake drains into the Presumpscot River (Figure 1).

As mentioned above, the present 89 m (267 ft) altitude of Sebago Lake is the result of the lake level having been raised by a dam. The preglacial drainage for the Sebago Lake basin probably followed a route to the south end of the lake as suggested by the drainage pattern on Figure 2 and by the fact that the south end of the lake contains a buried bedrock valley. This valley is indicated on side-looking radar surveys of the U.S. Geological Survey (unpublished data, 1995). It is now filled by ice-contact glaciomarine delta deposits.

As summarized by Thompson and Borns (1985b), "The offlap of the sea from southern Maine began soon after the late Wisconsinan ice margin had receded to the marine limit. The marine submergence reached its maximum extent at about 13,000 yr B.P., and it is likely that isostatic crustal uplift was already causing relative sea level to fall by this time. The latter in-

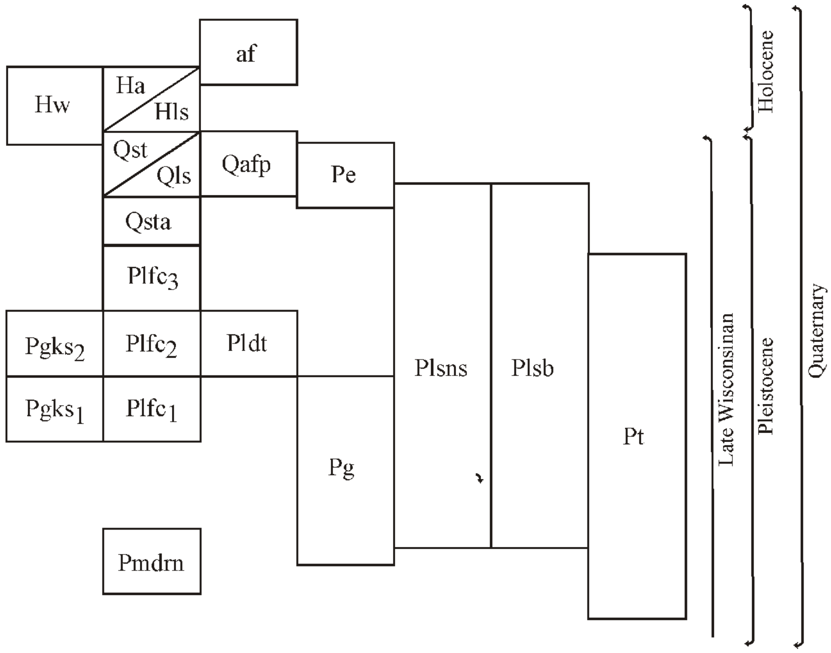

Figure 3. Correlation of map units.

ference is based on the gradient of the plane defined by glaciomarine deltas in southern Maine. The elevation pattern of the deltas indicates a northwest-southeast postglacial tilt of 0.47 m/km (2.48 ft/mi) across south-central Maine.... This value is considerably less than the postglacial uplift gradient of 0.89 m/km (4.67 ft/mi) obtained ... from glacial Lake Hitchcock deltas in the Connecticut River valley. The probable explanation for this discrepancy is that the sequence of marine deltas in Maine was graded to a falling sea level, thus reducing the apparent crustal tilt as determined from their present elevations."

Most glacial meltwater deposits in the Naples area are graded to an elevation consistent with the 95-98 m (310-320 ft) East Sebago col and with a glacial Lake Sebago shoreline that rises to the north at a rate slightly less than that of Lake Hitchcock in the Connecticut Valley. Glacial Lake Sebago shorelines grade closer to 0.85 m/km (4.49 ft/mi), based on beach deposits at around 107 m (350 ft) in kame-delta deposits of the Crooked River valley ($Plfc_3$) just north of the quadrangle near Edes Falls. Many other scattered beach and nearshore features fall at elevations consistent with this strandline (for example, beach deposits at 107+ m (350+ ft) near Arrowhead Point on Long Lake; fan-delta deposits of Tarkiln Brook at 107+ m (350+ ft); a small meteoric delta deposit at 104+ m (340+ ft) at the mouth of Sebago Cove; a beach or spit at 95+ m (310+ ft) south of the cemetery near Dingley Brook; the spit at 92+ m (300+ ft) at the west side of the mouth of the large horseshoe swamp southwest of Songo Lock; and the cobble apron around the shore at the north side of that swamp associated with infilling from the south).

If the transgressive sea reached the Naples quadrangle, it regressed from the area somewhat before 11,450 yr B.P. This conclusion is based on shells that indicate the approximate offlap of the late Wisconsinan sea at Little Falls, Gorham, less than 32 km (20 mi) southeast of Naples (Smith, 1985; Thompson and Borns, 1985a).

GLACIAL AND POSTGLACIAL DEPOSITS

The succession of Pleistocene and Holocene surficial deposits in the Naples area is given in the correlation chart (Figure 3) showing the relative ages of the map units.

Till (map unit Pt) occurs throughout the Naples area. Its thickness is variable, as is its composition. The till was deposited from the glacial ice sheet and forms a blanket over the underlying bedrock; it is inferred to underlie younger deposits throughout the area. In most exposures in the Naples area, this till is light olive-gray, sandy, stony, and moderately compact, showing weathering only in the uppermost few feet. The sandy texture reflects its derivation from coarse granitic rocks of the Sebago pluton. A very good 2-6 m (6-20 ft) exposure was present at the Sebago-Pacific Trucking Company lot about 1.6 km (1 mi) north of Songo Lock (Site 11 on the materials map).

Some drumlins are found in the Naples area, but most hills that are drumlin-shaped (and oriented in the expected direction for drumlins relative to the direction of striations in the area) have bedrock cores that have been plastered with till. Many more of these rock-cored hills exist in the quadrangle than do true drumlins.

Distal lake-bottom sediments of glacial Lake Sebago (map unit Plsb) form a discontinuous cover as much as 18 m (60 ft) thick throughout the Crooked and Songo River basins. These deposits are also scattered around the margins of Long Lake (more than 19 km [12 mi] north of Naples), and around parts of

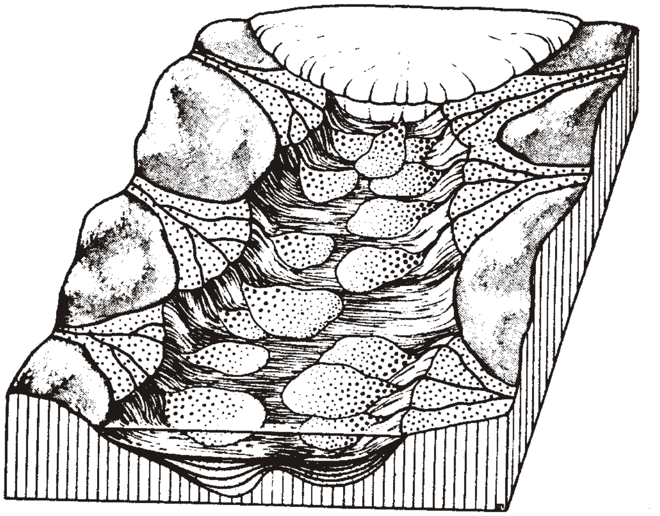

Figure 4. The density underflow pattern suggested here for the subaqueous outwash fan deposits in glacial Lake Sebago is depicted "...for a portion of one summer. During the rest of the summer and in succeeding years, fans would continue to overlap and interfinger with each other." Diagram and quote from Ashley (1975, Figure 17).

Brandy Pond and Sebago Lake (especially in the area west of Kettle Cove, the northwest side of Raymond Neck, Dingley Brook, and the inlet to Sebago Cove). These fine-grained sediments generally overlie till and can be found overlying, underlying, and intertonguing with coarser proximal-distal glacial lake deposits, including glacial-lake shoreline and nearshore deposits (unit Plsns) and kame-terrace, kame-delta, fan-delta, and outwash deposits (units Plfc, Pldt, and Pgks), as seen in borrow pits.

Stratified deposits that both underlie and intertongue with the lake-bottom materials are considered to be subaqueous outwash sediments, such as the density underflow deposits (Figure 4) described by Ashley (1975). In the model shown in Figure 4, meltwater from the ice sheet at the north end of the glacial lake pours sediments into the lake as subaqueous fans, while tributary streams build deltas into the middle and south sections of the lake.

In the Naples area, only minor deposits were contributed by tributary streams after the glacier moved north of the quadrangle; these include part of the Tarkiln Brook deposits (unit Pldt), which were laid down by water draining Parker Pond, and meteoric deltaic deposits at the mouth of the small unnamed stream in Songo Cove. Nearly all the other coarse-grained (non-lake-bottom) water-laid deposits in the Naples area are proximal or distal glacial meltwater deposits. Proximal ice-contact deposits include the glaciomarine(?) delta or fan deposits on Raymond Neck (unit Pmdrn), glaciofluvial and glaciolacustrine kame terrace deposits of the Songo River Valley (unit Pgks), and glaciofluvial and glaciolacustrine fan deposits of the Crooked River Valley (unit Plfc). In the Naples area, only deposits of the Songo River valley (Pgks), Raymond Neck (Pmdrn), Tarkiln Brook (Pldt), and the third stage of outwash fan deposits in the Crooked River Valley ($Plfc_3$) were built up to the water surface and above.

Shoreline and nearshore deposits (unit Plsns) are derived from earlier glacial deposits that have been reworked by waves and currents in glacial Lake Sebago. Many of the original materials were proximal subaqueous fan deposits. One such deposit, about 1.6 km (1 mi) north of Songo Lock, contains a buried esker that has been almost completely excavated. This same area also has sedimentary structures indicating northeastward current flow, and an interesting boulder dropstone that punched a significant dimple in the underlying sand and silt beds. Sand-silt beds are draped over this large dropstone. The boulder dropped from an iceberg floating 3-6 m (10-20 ft) above on the lake's surface.

As the continental glacier retreated northward, the sediments that flowed down the Crooked River and reached the Naples area became finer grained, and ice blocks buried by the earlier sediments melted, leaving kettle holes that filled with varved silt-clay drape deposits. At least 130 varves were counted in one exposure in the quadrangle. Thus, glacial Lake Sebago existed for at least 130 years, and probably much longer. This subject bears further investigation, but is beyond the scope of this report. When the base level for glacial Lake Sebago dropped, the Crooked and Songo Rivers began to cut down through the outwash deposits in their valleys. These rivers cut and built stream terraces of at least four successive levels, of which only two are shown on the map. It is not clear whether the lake level dropped all at once or in several stages; further investigation may clarify this matter.

The uppermost mapped stream terrace deposits (unit Qsta) were well exposed southwest of Cook Mills in the P&K Borrow Pit in $Plfc_2$. Here, 3 m (10 ft) of silt-clay varves were incised by a stream channel that was subsequently filled by sand units. The latter sands slid partly down the channel walls and were subsequently cut again by channels, which were filled by stream terrace sand and gravel. The lower mapped stream terrace unit (unit Qst) actually includes several terrace levels lumped together because they are difficult to separate out at the scale of the map. However, several noticeable channels and remnants of meanders are evident in various parts of this unit, especially in the area just north and south of where the Crooked River passes under Rte. 302.

When the downcutting Songo River reached the lowered Sebago Lake, it began to build a delta and some beach deposits (unit Qls) into the lake. The Quaternary beach deposits shown on the map are on grade with stream terrace deposits (unit Qst), but are slightly higher than the modern beach deposits (unit Hls). This suggests that Lake Sebago reached its modern pre-dam elevation through a gradual lowering of the postglacial lake level. The Songo River delta was drowned when the lake was dammed and raised to its present level. The approximate front edge of the drowned delta is delineated on the geologic map.

When glacial Lake Sebago drained, the fine-grained lake-bottom sediments in the Crooked River valley became exposed to wind erosion. As a result, generally thin deposits of wind-blown sand developed, mostly on the east side of the valley in the vicinity of Mill and Decker Brooks. In particular, a remarkable dune field (unit Pe) formed on Tenny Hill at this time.

Several other Pleistocene and Quaternary deposits are found in the quadrangle, including a fan deposit (unit Qafp) on the east shore of Parker Pond. This deposit may have begun to form before glacial ice melted out of the area, but continued to develop afterward as an alluvial fan deposit. As the ice melted out of Parker Pond, meltwater flowed southwestward down the headwaters of Tarkiln Brook and built a fan delta (unit Pldt) into glacial Lake Sebago. Then as the ice margin receded northward into Pleasant Lake in the Casco quadrangle, a lower outlet was uncovered near the headwaters of Mill Brook in the Casco quadrangle, so meltwater drainage shifted from Tarkiln Brook to Mill Brook. Both Tarkiln and Mill Brooks are now underfit streams relative to the size of their valleys.

Deposits of Holocene age are generally associated with modern streams, wetlands, and lake shorelines. Freshwater swamp deposits (unit Hw), characterized by accumulations of decayed organic matter, are scattered throughout the area. Alluvial deposits (unit Ha) of variable thickness and composition underlie the flood plains of most modern streams. It should be noted that both swamp and alluvial deposits are coincident along many stretches of flood plains in this area, particularly in the Crooked and Songo River valleys. These rivers are graded to the present level of Sebago Lake and are meandering streams, which is the common pattern formed by streams crossing relatively low-gradient, wide plains underlain by unconsolidated and fine-grained deposits such as those in the Naples area.

Modern beach deposits (unit Hls) have formed along scattered stretches of lake shorelines, especially around Witch Cove and the beach areas of Sebago Lake State Park near the Songo River delta. Both the beaches and delta are active and have been studied recently (Thompson and others, 1995a, b). The beach nearest the mouth of the Songo River has shown signs of erosion, which has been attributed to seasonal fluctuations of Sebago Lake's water level (Thompson and others, 1995a, b). The present author has observed much modern erosion along the Songo and Crooked riverbanks, as well as along the shoreline of Sebago Lake. As a result, fresh exposures of striated bedrock are common, especially on the shores of islands. The shoreline erosion around the lake may be attributed to the damming of the lake.

Finally, areas have been mapped as artificial fill (unit af) where the original ground surface is covered by a substantial thickness of imported materials, both manmade and natural, that have been used by man to fill depressions, or where the surface has been so altered by construction as to obliterate the original landscape.

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APPENDIX: DETAILED SITE OBSERVATIONS AND SELECTED WELL AND SEISMIC DATA
(Refer to surficial materials map [Hildreth, 1998] for locations)

SITE NUMBER

1 - P&K Borrow Pit -— This pit is located in the north-central part of the quadrangle, immediately southwest of the junction of the Crooked River and Mill Brook. The pit has been visited by geologists many times over the past 20 years (Thompson and Smith, 1977; and Thompson and others, 1995a, b). In 1995, one face of the pit contained 1-1.5 m (3-4 ft) of silt-clay varves (totaling 16 in number, each being 5-7.5 cm [2-3 in] thick) overlying 20 cm (8 in) rippled sand overlying 2.4 m (8 ft) of varves (totaling 46 in number, each being 5-10 cm [2-4 in] thick). The clay layer of each lamina is very thin (1-5 mm thick) and the top is brown. Nematode worm tracks are present in some laminae. The varve deposits fill a depression on the surface of sand deposits that are exposed within 30 m (100 ft) northwest of this exposure, where there is a 12 m (40 ft) sand bank. The varves are cut by younger sand deposits within 30 m (100 ft) to the northeast, where a 7.6 m (25 ft) sand bank of dipping beds comprise a channel-fill deposit. A few layers of the varves have convoluted bedding, but most are horizontal or dip parallel to the underlying drape surface. These deposits have been faulted and folded slightly through slumping and settling. Postdepositional Liesegang banding (rust-colored, rhythmic iron-oxide precipitate bands that are parallel to one another but not to bedding, straight or curved, and variable in orientation) is common throughout the deposits in this pit.

2 - Dragon Pit North -— This large pit (about 1.6 km [1 mi] north-northeast of Songo Lock) is part of an excavation complex associated with the Dragon Concrete Company. Excavation in the pit area has mostly been discontinued. The northeasternmost section includes an exposure of 1.5-3 m (4-10 ft) of fine sand, silt and sand over 2.4 m (8 ft) of pebbly sand and gravel extending down to the water table, below which appears to be several more feet of pebbly sand. From here southward, including a long trench south of the road, there appears to have been an esker, which has been mined out. Just 91 m (300 ft) northwest of the road, an exposure of about a meter of dune sand overlies 2.2 m (7 ft) of laminated sand, silt, and pebbly sand. Here, a boulder dropstone (1 m [3 ft] in diameter) is near the top of the laminated unit, which also contains small faults, sand-pebble dikes, convoluted bedding, and abundant Liesegang banding throughout.

3 - Dragon Pit South -— Located just south of Site 2. About 91 m (300 ft) south of the road through the pit area, 1 m (3 ft) of fine windblown sand overlies 1 m (3 ft) of roughly laminated silt and clay, which in turn overlies 0.6 m (2 ft) of sand, silt, and clay beds, over more than 1 m (3 ft) of well-laminated silt and clay. This exposure is on the west side of the trench from which the inferred esker mentioned in Site 2 has been excavated. Current bedding in part of this exposure indicates northerly flow.

SITE NUMBER

4 - Edes Falls Pit -— Located on the border of the Naples and Casco quadrangles, on the west side of the Crooked River, this pit is owned by P&K Sand and Gravel, Inc., of Naples. The pit is a long north-trending trench that is more than 0.5 km (0.3 mi) long and 6-12 m (20 to 40 ft) deep. The north and south ends of the pit are not currently being mined, but the material exposed in the central part suggests that the mined-out sections probably constituted an esker (ice-channel filling) core of coarse-grained sand and gravel similar to that in the Dragon Pits. The material exposed in the banks of the pit is predominantly sand and silt plus minor sand and clay. The pit has been excavated in a relatively flat-topped terrace (elev. approximately 100-107 m (330-350 ft) and is composed of glaciofluvial and glaciolacustrine deposits capped by a thin veneer of windblown sand. Thin-bedded silt and clay varves overlie the glaciofluvial deposits and occupy depressions in the terrace surface. The depressions are kettle holes underlain by faulted and folded glaciofluvial sand and gravel deposits. Bedrock is exposed in the floor of the pit.

Near the pit entrance, a 60-cm (24-in) unit of silt-clay varves drapes over 2 m (6 ft) of variable, faulted sand. Manganese and iron-oxide staining and cementation are found along and near the contact. Silt-clay rhythmites here have peculiar faint parallel, thin rusty lines 1-4 mm apart (Liesegang banding). At the far western edge of the pit, 9 m (15 ft) of fluvial pebbly-sand beds (and very minor pebble-cobble gravel and a few boulders) display large-scale cross stratification, including cut-and-fill channels more than 6 m (20 ft) across. At about the center of the pit, a 15-m (50-ft) wide section contains the following units (from top to bottom): about 2 m (6 ft) of concave, slumped, and folded thin-bedded silt, clay, and fine-grained sand rhythmites; about 3 m (10 ft) of slumped and faulted sand; about 60 cm (24 in) of undisturbed, horizontally bedded silt and clay; and 60-90 cm (24-36 in) of thin-bedded sediments that have Type B climbing ripples indicating deposition by south-flowing currents. A probable boulder-pebble beach gravel (about 1 m [3 ft] thick) caps the western wall of the pit at about an elevation of 107 m (350 ft), which would indicate a glacial-lake shoreline at this level.

5 - Pit northeast of intersection of Route 302 and the Crooked River -— This is a privately owned pit about 12 m (40 ft) deep that is worked sporadically, About 3 m (10 ft) of pebbly sand overlies about 6 m (20 ft) of sand, fine sand, and silt, which in turn overlies 3 m (10 ft) of pebbly sand. One depression at the top of the pit contains more than 26 draped silt-clay varves that are each 2-6 cm (0.8-2.4 in) thick. Overall, very little other than sand is found in this pit. Beds are rhythmically bedded on a large scale from pebbly sand to very thin clay layers. Beds dip generally south-southwest.

SITE NUMBER

6 - Well-location 12-3 from Williams and Lanctot (1987) -— Records for this well show 7 m (23 ft) of sand over 8.5 m (28 ft) of sand and clay over 4 m(12 ft) of sand, clay, and gravel.

8 - Crooked River cut-bank exposure near road, upstream from Songo Lock -— Exposed by the river are the following: About 1 m (3-4 ft) of windblown and fluvial sand at the top; 2 m (6-7 ft) of silt-clay varves, which contain very few pebbles and minor sand; 1 m (3-4 ft) of slumped section in which a 1-m boulder rests on the shoreline of the river; the waterline; and below the waterline at least 1 m (3 ft) of varves are visible. The varve section is draped into a shallow depression and is slightly folded with few folds and convoluted beds. The upper 2 m (6-7 ft) silt-clay varve unit has at the top 18-20 varves in a 1'10" thickness over 10 varves in a 2" thickness over 20 varves in a 3" thickness over 20 varves in a 6" thickness over 20 varves in a 9" thickness (more than 0.5 cm each) over 20 varves in a 1'8" thickness (0.5-2cm each) over 20 varves in a 3' thickness (2-6 cm each).

9 - Crooked River cut-bank exposure northeast of Site 8 -— The uppermost part of the bank is covered. About 2 m (6 ft) above the waterline, 0.8 m (2 ft) of nearly horizontal, thinly bedded sand overlies more than 1 m (4 ft) of thinly bedded sand and silt-clay units that dip southwest. The waterline was about 0.9 m (2-3 ft) lower than normal at the time of observation.

SITE NUMBER

10 - Crooked River cut-bank exposure north of Site 9 -— The water level was about 0.9 m (2-3 ft) lower than normal. Exposed from the water level upward were the following: 1.3 m (4 ft) of poorly bedded sand, fine sand, silt, and muck containing rotted wood fragments; 3 ft of fine sand, silt, and muck containing buried tree roots; overlain by 2 ft of fine sand and silt containing modern live tree roots. Two superposed soils appear to be present here, the bottom one containing the roots and stumps of trees as well.

11 - Sebago-Pacific Till Pit -— Located about 1.6 km (1 mi) north of Songo Lock and the junction of the Crooked and Songo Rivers, the pit is owned by Sebago-Pacific Trucking Co., Inc. It exposes 2-6 m (6-20 ft) of massive glacial diamict (till) that is light olive-gray, sandy, stony and moderately compact. The pit face is very steep on account of the compactness. The uppermost meter shows evidence of modern soil formation, but below that, the till is unweathered except for some clasts of diabase-basalt dike material, which commonly have spalling spheroidal weathering rinds. Boulders (some as much as 3 m [10 ft] in diameter) of the most common rock type in the region (Sebago granite) are common throughout the exposure. The abundance of boulders in this pit is greater than normal for till deposits in the region. The till here does not display any obvious fissility, and very faint stratification is present in a few places.