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Contents: 19 p. report

Surficial Geology of the Cornish 7.5-minute Quadrangle, Cumberland, Oxford, and York Counties, Maine

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INTRODUCTION

This report describes the surficial geology of the Cornish 7.5-minute quadrangle in southwestern Maine. The surficial materials in the study area consist of unconsolidated sediments that were principally deposited by glaciers and their associated meltwater streams at the end of the Pleistocene epoch.

Surficial mapping in this area was started by William R. Holland in 1983 as part of a sand and gravel aquifer mapping project conducted by the Maine Geological Survey. Holland's aquifer mapping was included in a report by Williams and others (1987), but his untimely death in 1989 prevented him from completing work on the surficial map. Mapping was completed by Robert M. Newton during the summers of 1992 through 1996 as part of the COGEOMAP program of the Maine Geological Survey and the U.S. Geological Survey. Both a surficial geologic map (Newton and Holland, 1997) and a materials map (Newton, 1998) have been prepared at a scale of 1:24,000 using the 1964 USGS edition (photorevised in 1989) of the Cornish quadrangle as a base map.

This report describes the map units and details the glacial and postglacial history of the quadrangle. Previous work in the area was done by Stone (1899), Williams and others (1987), Eaton and Baker (1981), Holland (1986), and Canwell (1997).

Location and Physiography

The Cornish quadrangle is located in southwestern Maine and includes parts of Cumberland, York, and Oxford Counties and portions of the towns of Cornish, Hiram, Baldwin, Limington, and Parsonsfield. The quadrangle covers all of the area between latitude 43°45' and 43°52'30" north, and between longitude 70°45' and 70°52'30" east.

[1]Deceased

The area is composed of numerous hills rising to elevations of approximately 1,200 ft. The highest elevation is Mt. Cutler (1,232 ft) at the northern edge of the quadrangle, with the Saddleback Hills a close second at 1,220 ft. Two major rivers flow through the quadrangle. The Saco River enters from the north and exits near the southeast corner of the map area. The Ossipee River enters from the west and joins the Saco just east of the center of Cornish. The lowest elevation is 280 ft where the Saco exits the quadrangle.

SURFICIAL GEOLOGY

Till and end-moraine deposits (units Pt and Pem)

Till (map unit **Pt**) is unsorted, unstratified sediment deposited directly by glacial ice. It mantles much of the bedrock surface except at higher elevations and on steeper slopes where bedrock is exposed at the land surface. In the Cornish quadrangle, till or bedrock is exposed at the surface over more than 50% of the area. In addition, a thin layer of till frequently lies between glaciofluvial sand and gravel deposits exposed at the surface and bedrock below.

Till can be deposited in a number of different ways and may have a wide range of characteristics. Lodgement till is deposited directly beneath actively moving glacial ice and therefore tends to be compact with a relatively high concentration of silt and clay (up to 50%). Ablation till accumulates on the surface of melting ice and is eventually deposited as the ice melts. Washing out of silt and clay by the action of meltwater causes ablation till to have a much higher sand content than lodgement till. It is also less compact.

Thick deposits of till (10 ft) can occur on the lower hillside slopes and as streamlined hills termed drumlins. The long axis of a drumlin is oriented parallel to the direction of ice flow. Although classic drumlins are virtually absent from this area, many of the bedrock hills have elongated till ramps on the side from which the ice flowed (upglacier side). For example, Towles Hill just south of the Ossipee River has a broad ridge extending northwest from the summit. This thick till ridge is parallel to the direction of ice flow and thus is classified as a drumlinoid feature.

Thick till can also accumulate at a stable, active ice margin to produce moraines. In general, moraines are uncommon in regions that lie inland from Maine's coastal lowland, as the glacier tended to undergo stagnation-zone retreat (Koteff and Pessl, 1981). However, a hummocky, bouldery till area just southeast of Cornish village has many of the characteristics generally associated with end moraines. Holland (1986) classified these deposits as "ice-disintegration moraine." They are mapped as morainal ridges (unit **Pem**) in the present report because they appear to have formed at the end of a tongue of ice lying within the Saco River valley near the eastern border of the quadrangle.

Glacial-Fluvial Deposits

These deposits are sorted sands and gravels deposited by glacial meltwater streams. They are stratified and commonly have cross-bedding suggestive of braided stream deposition. They can be deposited in a variety of topographic forms depending on the position of the meltwater stream relative to the ice.

Ice-Contact Deposits (unit Pgi): These are sediments deposited by meltwater streams in intimate association with ice. The material generally has a wide range in grain-size and sorting characteristics. It is generally stratified, but the stratification is commonly disrupted by high-angle normal faults which formed during the melting of ice either adjacent to or under the deposit. These features usually occur as isolated deposits on the sides of hills or valleys.

Eskers (Pge series): Eskers are sinuous ridges of sand and gravel formed by meltwater streams flowing within or under glacial ice. Eskers in the Cornish quadrangle are up to 100 ft high and 4500 ft in length, and most are less than 200 ft wide. They exhibit both meandering and braided channel patterns. In many areas there is clear evidence that the eskers were deposited by meltwater streams flowing up and over ridges. This suggests that in these systems the flow was hydrostatically controlled.

The eskers in the Cornish quadrangle have been divided into two discontinuous systems, each of which is thought to have been deposited within part of a single glacial drainage system. The eskers almost exclusively occur south of the Ossipee River in areas which are currently drained by north-flowing streams. Although only a few sedimentary structures were observed to indicate the direction of meltwater flow, it appears that all the flow in the eskers was to the south. The Spruce Pond System (**Pgesp**) was formed by meltwater flowing south through the area around Wedgwood Brook in the southwest part of the quadrangle. Meltwater in this esker system appears to have exited from the quadrangle after flowing through a meltwater channel in a gap in the bedrock ridge just north of Long Pond.

The Pugsley Brook System (**Pgepb**) lies just to the east of the Spruce Pond System in the area of Pugsley and Merrifield Brooks. Most of the meltwater in this system appears to exit the quadrangle to the south in a meltwater channel just east of Hosac Mountain, although some meltwater may have exited eastward through a second meltwater channel into the Steep Falls quadrangle.

Glacial-Fluvial Sand and Gravel Deposits (Pg series): These are sediments deposited by meltwater streams in close association with ice. The material typically ranges from moderately well-sorted to poorly-sorted coarse sand and gravel. The deposits are commonly kettled and fill the valleys in which they are found, with deposits extending as much as 100 ft higher than the modern streams which cut them.

Glacial-Lacustrine Deposits (Plb and Plb series)

Glacial-lacustrine deposits include both deltas (**Pld** series of map units) and lake-bottom sediments (**Plb** series). The deltas formed where streams entered a lake and deposition occurred in response to a decrease in stream velocity. These deposits include relatively coarse sands and gravels in horizontally stratified topset beds which overlie sandy foreset beds that were deposited on the delta front. The foreset bed deposits are generally much thicker than the topset deposits. The contact between the topset and foreset beds lies at approximately the former lake level. Geomorphically, the deltas are flat-topped features except where they have undergone collapse near the ice front or been extensively dissected by postglacial drainage. Lake-bottom deposits in this area are generally fine, laminated sands and silts.

Varves are annual couplets of fine sand and silt alternating with clay which form at the bottom of a glacial lake. The fine sand and silt deposits represent deposition in the spring and summer when meltwater entering the lake carries a high suspended sediment load of coarser material. This sediment is distributed across the bottom of the lake by turbidity currents. Meltwater flow into the glacial lakes in winter is dramatically reduced and thus there is little addition of new sediment. Deposition during the winter principally involves clay-sized material which slowly falls out of the water column and is deposited on the bottom of the lake. The varve couplets are annual, and counting the number of varves can indicate how long the glacial lake was in existence. However, not all glacial lake sediments are varved.

Varved clays have been observed at three separate locations in the quadrangle, all associated with glacial Lake Cornish. The "piggery pit" exposure located in the village of Cornish was first described by Holland (1986) and contains 19 ft of varves starting at an elevation of approximately 325 ft. This varve series underlies a delta sequence of sand and pebble gravel/fine sand. A thick sequence of cobble and boulder gravel lies under the varves. The original surface at the top of the exposure is the

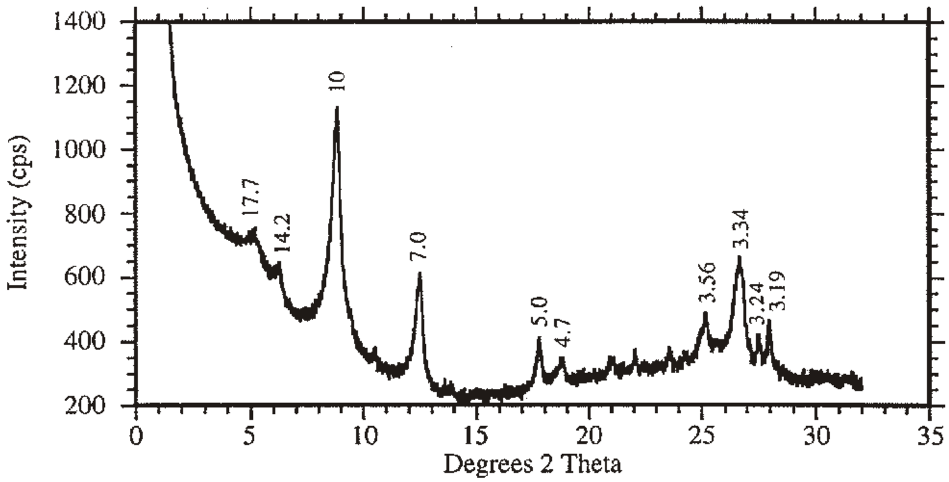

Figure 1. X-ray diffractogram of an oriented <1 m sample of a winter layer in the Saco River varve outcrop. The sample has been treated with ethylene glycol in order to identify expandable minerals. The 17.7 Å peak is from smectite or an expandable vermiculite. Other phases present include chlorite, illite, and kaolinite.

easternmost extension of the Lake Cornish deltas (unit **Plcd**). The second varve exposure is in the eastern cutbank and stream bottom of the Ossipee River, approximately 3,000 ft upstream of the confluence with the Saco River at an elevation of 290 ft. The third varve exposure is in a cutbank on the west side of the Saco River, just downstream from the Route 5/117 bridge, at an elevation of 270 ft. At this exposure, 9 ft of stream alluvium overlies 8 ft of varves representing about 25 years of deposition.

One of the basic questions at this third site is what was the environment of deposition for these varves? Are they lacustrine, marine, or estuarine? Their elevation of 270 ft is considerably below the marine limit elevation (310 ft) as determined from the topset-foreset contact in the North Limington Delta, located approximately 9 mi down the Saco Valley. A second question concerns the relationship of these deposits to those at the "piggery pit." Although located close to each other, the two sites are separated by 55 ft vertically and lie on opposite sides of a kettled delta (unit **Plsd**) which occurs at the confluence of the Ossipee and Saco Rivers. Holland (1986) used the presence of the kettled deposits to suggest that the lacustrine episode preceded the last glaciomarine episode. Although this explanation works well for the deposits in the Ossipee River valley, it is difficult to see how it will work in the Saco River valley where the kettled deposits are located. It is most probable that all these varves were deposited in glacial Lake Cornish although not necessarily at the same time. The "piggery pit" varves may have formed earliest, when Lake Cornish was dammed by ice in the Saco River valley. The coarse gravel underlying the varves at this location was probably derived from meltwater associated with the Saco River valley ice. Downwasting of this ice resulted in expansion of the lake and the formation of the varves at the Saco River outcrop. It is unlikely, although possible, that the Saco River outcrop varves were deposited in an estuarine situation. We believe that the Cornish Moraine (map unit Pem) prevented the infiltration of marine waters into the Cornish quadrangle. X-ray diffraction analysis of clay from the Saco River outcrop (Figure 1) indicated that vermiculite is likely present in this sediment, and vermiculite is generally not found in marine environments.

Glacial Lake Cornish (units **Plcd** and **Plcb**) initially formed when the ice front had retreated from the Ossipee River valley west of Cornish, but a tongue of ice still lay in the Saco River Valley extending just south of the confluence with the Cornish moraine. The tongue of ice in the Saco Valley gradually downwasted and the lake was later dammed by the moraine. Eventually the dam eroded and the lake drained. The elevation of glacial Lake Cornish was approximately 350 ft and the lake extended up the Ossipee River valley at least as far west as Kezar Falls.

The lake was almost completely filled by prograding deltas (**Plcd**) from sediment carried eastward by meltwater streams following the Ossipee River. Geomorphically these are large sand plains which were later dissected by the modern Ossipee River. The fairgrounds in Cornish lie on this old delta surface.

Glacial Lake Pigwacket (Thompson, 1999a,b) occupied the Saco River valley above Great Falls in the northern part of the quadrangle and extended northward to the Fryeburg area. The lake was probably dammed by glacial-fluvial sand and gravel blocking the Saco Valley between Cornish and Great Falls. Exposures in deltas (unit **Plpd**) just north of Great Falls indicate a lake level near 400 ft.

A smaller glacial lake occupied the area around Spruce Pond in the southwestern corner of the quadrangle. This small lake was dammed by the receding ice margin and by glacial-fluvial sand and gravel deposits (unit **Pgsp$_2$**) which blocked the lower part of the Wedgwood Brook valley. The lake initially drained southward through a meltwater spillway at 550 ft and later through a spillway at 510 ft. Eventually the glacial-fluvial sand and gravel dam failed and the lake drained, leaving Spruce Pond as it appears today.

Holocene Deposits

Alluvium (unit Ha): Alluvium is sediment deposited by modern streams. It is composed mostly of sand and silt, although coarser gravels can occur on steeper slopes.

Freshwater Wetlands (unit Hw): Freshwater wetlands are areas where thick organic deposits accumulate due to high water-table conditions. These areas can occur in areas underlain by either till or stratified drift. Some of the wetlands occur in kettle holes in stratified drift which have become mostly filled with bog vegetation. In some instances these bogs are underlain by significant thicknesses of peat. Wetlands underlain by till generally have much thinner accumulations of organic sediments.

GLACIAL AND POSTGLACIAL GEOLOGIC HISTORY

The Pleistocene Epoch began approximately 1.7 million years ago and ended about 10,000 years ago. During this time Maine undoubtedly was subjected to multiple advances and retreats of glaciers. However, most of the landforms we see today were created during the last glacial event (late Wisconsinan glaciation). During late Wisconsinan time the Laurentide Ice Sheet advanced over the entire area, reaching offshore all the way to the break in slope at the continental shelf (Thompson and Borns, 1985a, 1985b).

Regional ice flow was to the southeast (Thompson and Borns, 1985a). This agrees with the orientation of drumlins and glacial striations measured in the Cornish quadrangle. Cross-striations were observed in a number of locations. In general, the earlier striations indicate a southeasterly direction (107-145^{o}) of ice flow, while later flow tended to be more southerly (158-180^{o}). The later striations probably reflect local variations in ice flow caused by thinning of the ice near the terminus, while the earlier striations more likely indicate a regional ice flow. In general, the earlier striations are parallel to the elongate drumlinoid till ridges found on the stoss sides of some bedrock hills.

Retreat of the ice margin began approximately 17,000 yrs B.P. (years ago)(Thompson and Borns, 1985b) and the ice front had retreated to the present coast by approximately 14,000 yrs B.P. (Smith, 1985). Initially the ice front terminated in the late-glacial sea which transgressed the coastal lowland as the ice retreated due to isostatic depression of the land surface. By the time the ice front retreated into the adjoining Limerick quadrangle, it was no longer in contact with the sea (Wilch, 1999a,b). It is unlikely that any of the varves observed in the Cornish area are marine in origin. Recent paleomagnetic varve chronology work on the varves from Cornish by Canwell (1997) suggest that glacial lake Cornish formed approximately 12,450 years ago. If this date is correct it would mark the time that this area was deglaciated.

The oldest surficial materials in the area are till deposits (units **Pt** and **Pem**) associated with the last Wisconsinan glaciation. These deposits were formed by both lodgement and ablation processes, with the lodgement till probably being older than the ablation till. Although all till units in the quadrangle are probably time transgressive, they must be older than approximately 12,500 years.

Glacial-fluvial deposits were formed in association with the retreat of an ice margin characterized by the presence of a narrow zone of stagnant ice. Glacial-fluvial deposition in this zone resulted in the formation of fluvial and lacustrine morphosequences as defined by Koteff and Pessl (1981). In this style of retreat, ice-marginal positions are marked by heads of outwash characterized by ice-contact deposits. Eskers were deposited upstream from the heads of outwash by meltwater streams flowing in tunnels under the ice.

During the initial stages of deglaciation, meltwater streams flowed south across the southern part of the quadrangle forming the Pugsley Brook and Spruce Pond esker systems (units **Pgepb** and **Pgesp**). These two systems are essential synchronous, with the eskers of each system forming first and then followed by the ice-contact and lacustrine sediments.

Meltwater that deposited the Spruce Pond esker system spilled through the meltwater channel (550 ft elevation) east of Long Pond, forming a series of ice-contact deposits (unit **Pgi**) extending southward into the Limerick quadrangle. As the ice thinned and retreated, the ice-contact glaciofluvial complex (unit $\mathbf{Pgsp_1}$) north of the meltwater channel was formed. Some of the meltwater may have escaped eastward into the Little River valley, where it then spilled southward through the divide at the south end of the valley.

As the ice rapidly retreated from the head of unit $\mathbf{Pgsp_1}$, a small glacial lake formed in the Spruce Pond area, into which units **Plspb** and **Plspd** were deposited. The ice retreat had uncovered a lower outlet into Long Pond by this time, and the water level in Spruce Pond was about 510 ft. The ice front appears to have paused near the north end of Wedgwood Brook, where a large ice-contact/head-of-outwash complex (unit $\mathbf{Pgsp_2}$) was deposited. Deltas (**Plspd**) at the south end of this complex built into the Spruce Pond glacial lake, indicating a lake level of approximately 500 ft. Meltwater discharging out of the lake through the lower outlet into Long Pond caused erosion of the Pgi deposit at the east end of this pond, and the water level in Long Pond fell to approximately 480 ft (as indicated by a delta at the west end of the lake, **Pllpd**). Continued erosion of the Pgi drift dam in postglacial times has lowered the level of Long Pond to its current elevation of 459 ft.

At approximately the same time as the above units were forming, meltwater deposition was occurring in the Pugsley

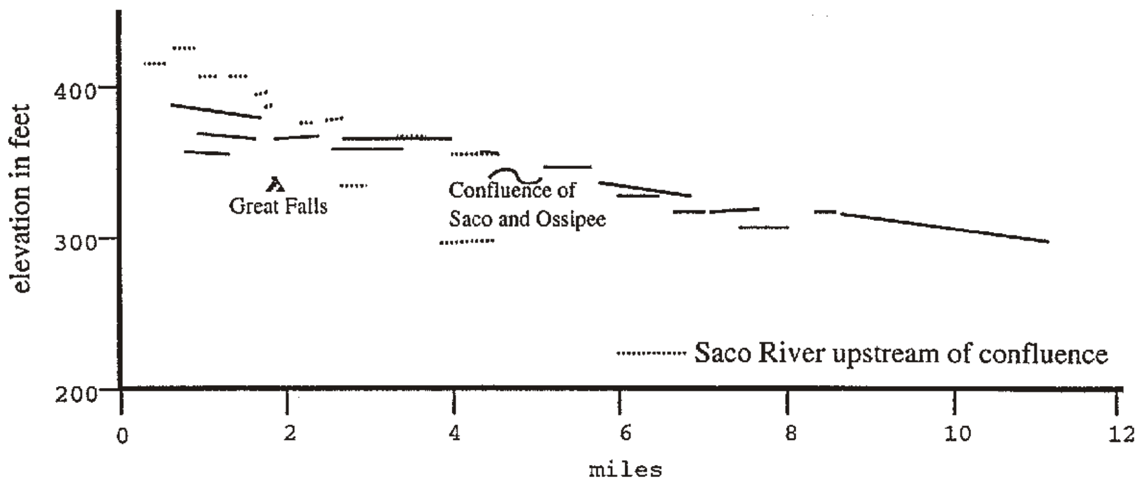

Figure 2. Profile of the surface elevation of stratified drift in the Ossipee and Saco River valleys.

Brook system in the southeast part of the quadrangle (unit **Pgpb**). Initially, meltwater escaped southward through a meltwater channel just east of Hosac Mountain. As the ice thinned, meltwater escaped directly east through a meltwater channel in the southeast corner of the quadrangle, and later directly east in the area near Gordon Cemetery. Eventually the ice retreated to the moraine complex (**Pem**) on the Saco River just southeast of the village of Cornish (Cornish Moraine). The glacier margin maintained its position at the Cornish Moraine for a longer time than it was maintained at the Spruce Pond head of outwash (**Pgsp$_2$**). This was due to the location of the moraine at the end of a north-south section of the Saco River valley, which is parallel to the direction of ice flow, as opposed to the location of the Spruce Pond head of outwash (**Pgsp$_2$**), which has a line of hills to the north (Bill Merrill Mountain, Mt. Misery, Peaked Mountain) that cut off the flow of ice. As the ice retreated from the Spruce Pond head of outwash, meltwater in the Ossipee River valley drained eastward, cutting a series of meltwater channels south of Cornish. The highest channel was cut at an elevation of 500 ft.

Glacial Lake Cornish formed as the Ossipee River valley became ice-free while ice still occupied the Saco River valley. The lake extended westward to at least Kezar Falls and flooded the Little River valley south of Cornish. Meltwater entering the lake from the Ossipee basin to the west carried large volumes of coarse sediment which was deposited as a delta/outwash complex that eventually completely filled the lake except for the Little River valley.

The stratified drift deposits (units **Plsd** and **Pgs**) filling the Saco River valley between the Cornish moraine and Great Falls have numerous kettles, suggesting that they are ice-contact features. One of the problems in interpreting these deposits is that they are at a lower elevation than the glacial lake Cornish deltas (unit **Plcd**) in the Ossipee River valley (Figure 2). Exposures of sedimentary structures in the Plsd deposits just north of the Cornish moraine suggest they are also deltaic. It is likely that the moraine served as a dam for this lake and that it may have also been contemporaneous with the lower stages of Lake Cornish. A sequence of meltwater channels (**c1**, **c2**) are cut into these deltas. The earliest channels are kettled, suggesting that the time between delta formation and lowering of base level to erode the channels was short. It also appears that the later channel of the Saco River flowed across the western part of the delta while the modern channel flows east of the delta. All this is evidence for rapid deposition and quick changes in lake level. Perhaps the lakes were subject to catastrophic filling and draining associated with subglacial outburst floods.

Deposits of glacial Lake Pigwacket (unit **Plpd**) occur north of Great Falls. The ice-contact deposits south of Great Falls appear to have provided the dam for the Lake Pigwacket system, which extended all the way north to the Fryeburg area. The northern extent of the ice-contact Pgs sediments at Great Falls marks an ice-margin position. Retreat from this position created the ever expanding Lake Pigwacket which trapped sediment and prevented the ice-contact deposits from being overwhelmed by outwash deposits.

Erosion of the Lake Cornish deposits occurred as the ice left the area and isostatic rebound raised the level of the land relative to sea level. A series of stream terraces (unit **Qst**) were cut as the Ossipee River eroded down to its current level. Small sand dunes (unit **Qed**) formed on some of the delta surfaces probably immediately following delta formation.

GROUND-WATER RESOURCES

Usable quantities of ground water can occur within both surficial sediments and bedrock. In the Cornish quadrangle, the glacial-fluvial and glacial-lacustrine delta units are likely to be the most significant aquifers as these materials are well-sorted, relatively coarse-grained, and tend to occur as relatively thick deposits. Till can potentially provide enough water for a singlefamily dwelling if the till deposit is sufficiently thick and permeable. However, water levels in till wells tend to fluctuate greatly, and they can run dry during the summer because the till has a lower specific yield than the sand and gravel deposits. The yield of bedrock wells varies greatly from place to place as this water comes principally from unevenly distributed fractures within the rock.

Potentially high-yield aquifers exist wherever glacial-lacustrine deltas occur. These features may be hydraulically connected to gravel deposits which possibly underlie the lake-bottom sediments. This situation is fairly common in other parts of New England and can be explained by the following depositional model. A thick ice-contact delta is formed during a pause in the retreat of the glacier. A lake then forms as the ice front begins a more rapid phase of retreat. A layer of gravel is deposited at the bottom of the lake by meltwater streams emerging from the ice front. This time-transgressive gravel may be covered by finer-grained lake sediments as the locus of glacial-fluvial deposition shifts back with the receding ice front. This results in a relatively thin glacial-fluvial gravel layer hydraulically connected to the earlier delta and overlain by lacustrine sediments. The area of the delta deposits represents the recharge area for the gravel aquifer beneath the lacustrine sediments. The lacustrine sediments may act as an aquitard, causing the glacial-fluvial aquifer to become confined.

Williams and others (1987) identified high-yielding aquifers in the Ossipee and Saco River valleys in the Cornish area with yields in excess of 50 gal/min. The complex stratigraphy in this area suggests that it is possible that some of these aquifers may be confined by the fine-grained lacustrine sediments.

SAND AND GRAVEL RESOURCES

Sand and gravel is the principal type of natural aggregate found in Maine. It is used in the construction of roads, bridges, railroads, and almost all commercial and residential buildings. According to Langer and Glanzman (1993), the value of aggregate production in the United States in 1990 amounted to approximately $9.1 billion. This is more than double the value of all precious metal production (gold, silver, platinum). Clearly, sand and gravel is one of the most valuable and important natural resources found in Maine.

The sand and gravel deposits are also important as they often form important aquifers from which we derive our groundwater supplies. The well-sorted and coarse-grained texture of these deposits create large pore spaces which can hold substantial quantities of water. Deposits of sand and gravel on the valley walls often serve as the recharge area for valley-bottom aquifers. Thus a clear understanding of the distribution of sand and gravel resources is necessary before informed decisions can be made concerning where mining is appropriate.

The Cornish quadrangle has extensive sand and gravel laid down by glacial meltwater in the Saco and Ossipee River valleys. These include the esker and ice-contact deposits (**Pge** and **Pgi**); the various glacial-fluvial and deltaic glacial-lacustrine map units (**Pg** and **Pld** series); and many areas mapped as stream terraces (**Qst**).

ACKNOWLEDGMENTS

We would like to thank the sand and gravel pit operators for their cooperation in allowing us to examine exposures created by their operations. The Estes and Maietta companies, in particular, allowed us access to their active pits. These exposures were extremely helpful in interpretting the glacial history of this area. We would also like to thank Woodrow Thompson for his constructve criticism of the text and his numerous field discussions.

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APPENDIX 2: LOGS OF FIELD OBSERVATIONS - Robert M. Newton

See surficial materials map of the Cornish quadrangle (Newton, 1998) for site locations.

Site #: 111 **Date:** 7/15/92 **Exposure Height:** 80 cm **Exposure Type:** Auger Hole
Location: On small woods road south of Great Falls-Hiram Dam. Small road cut in stratified drift.
Sediment Type: Sand + Gravel **Comments:**

Unit	sand and gravel			
Thickness	80+			
Size	-.5 to 0.5			
Sed. Structures	none observed			
Current Dir				
Comments	pebbles up to 3-5cm			

Site #: 110 **Date:** 7/15/92 **Exposure Height:** 50 cm **Exposure Type:** Auger Hole
Location: In woods south of Great Falls
Sediment Type: Sand + Gravel **Comments:**

Unit	sand and gravel			
Thickness	50			
Size				
Sed. Structures				
Current Dir				
Comments	Coarse poorly sorted, sand and gravel up to 5 cm diameter			

Site #: 115 **Date:** 7/15/92 **Exposure Height:** 50 cm **Exposure Type:** Auger Hole
Location: On flat-topped feature just NW of Hiram Dam. Went in on abandoned development road
Sediment Type: **Comments:**

Unit	Well-sorted sand occasional pebble			
Thickness	50 cm			
Size	1-2			
Sed. Structures				
Current Dir				
Comments	Unable to auger deeper as material was dry-lacks cohesion			

Site #: 119 **Date:** 7/15/92 **Exposure Height:** 160 cm **Exposure Type:** Auger Hole
Location: Just west of Saco River at north end of Quad in town of Hiram
Sediment Type: Sand **Comments:** Water table at 155cm depth

Unit	medium-fine sand			
Thickness	160			
Size	2.0			
Sed. Structures				
Current Dir				
Comments				

Site #: 120 **Date:** 7/16/92 **Exposure Height:** 80 cm **Exposure Type:** Auger Hole
Location: On flat-topped feature east of Hiram Dam
Sediment Type: Sand **Comments:** Could not find topographic knobs marked on map. Slumped RR cut all sand and gravel (5m). Feature extends eastward across the road.

Unit	Dry sand			
Thickness	80 cm			
Size	0.5			
Sed. Structures				
Current Dir				
Comments	dry sand lacked cohesion could not auger deeper			

Site #: 121 **Date:** 7/16/97 **Exposure Height:** 5.5 m **Exposure Type:** Stream Cut
Location: cut bank on Saco River just south of the Rt 117 bridge on west bank
Sediment Type: Varves **Comments:** Saco River alluvium overlies varves

Unit	fine sand and silt	gravel	varved	
Thickness	1 m	2 m	2.5 m	
Size				
Sed. Structures			cross beds and load structures	
Current Dir			S	
Comments	overbank deposits	alluvial gravels with some sand, cobbles 5cm	couplets are 10-15 cm. cross bed sets up to 2 cm thick	

Site #: 125 **Date:** 7/17/92 **Exposure Height:** 75 cm **Exposure Type:** Auger Hole
Location: South of Hiram Dam rest area on Rt 13. in flat topped feature west of tracks
Sediment Type: Sand **Comments:**

Unit	well-sorted coarse sand			
Thickness	75 cm +			
Size	.5 - 1.5			
Sed. Structures				
Current Dir				
Comments	dry sand prevented pickup in auger below 75 cm			

Site #: 126 **Date:** 7/17/92 **Exposure Height:** 85 cm **Exposure Type:** Auger Hole
Location: West of railroad tracks and south of Hiram Dam. South of site 125
Sediment Type: Sand + Gravel **Comments:**

Unit	sand and gravel			
Thickness	85 cm +			
Size	-0.5			
Sed. Structures				
Current Dir				
Comments	Ice-contact deposit			

Site #: 127 **Date:** 7/17/92 **Exposure Height:** 30 cm **Exposure Type:** Auger Hole
Location: west of railroad tracks, east of Saco River near till island just east of the Saco
Sediment Type: **Comments:**

Unit	coarse cobble gravel			
Thickness				
Size				
Sed. Structures				
Current Dir				
Comments				

Site #: 129 **Date:** 7/19/97 **Exposure Height:** 160 cm **Exposure Type:** Auger Hole
Location: West Baldwin, west of railroad tracks, east of Saco River
Sediment Type: Sand **Comments:**

Unit	Sand			
Thickness	160+ cm			
Size	1.5			
Sed. Structures				
Current Dir				
Comments				

Site #: 131 **Date:** 7/19/97 **Exposure Height:** 30 cm **Exposure Type:** Auger Hole
Location: West Baldwin, west of railroad east of Saco River, north of site 129. Hole is on top of a ridge between ponds
Sediment Type: Sand + Gravel **Comments:** Ice-contact topography.

Unit	sand and gravel			
Thickness	30 + cm			
Size				
Sed. Structures				
Current Dir				
Comments				

Site #: 132 **Date:** 7/19/92 **Exposure Height:** 10 m **Exposure Type:** Sand Pit
Location: Maietta sand and gravel pit
Sediment Type: Sand + Gravel **Comments:** appears to be ice-contact stratified drift 60% gravel. Some till exposed at the bottom of the exposure. Sediments folded into anticlines and synclines

Unit	well-sorted sand	sand and gravel	sand	Second pit face-Lacustine sand
Thickness	2 m	5 m	3 m	5 m
Size	1.0		1.0	3.0
Sed. Structures	plain beds	rounded imbricated pebbles	some cross-bedding	plain beds
Current Dir			S	
Comments		some beds dip up to 90 degrees	Steeply dipping faults cut this unit	Lacustrine sand lies unconformably on folded sand

Site #: 136 **Date:** 7/20/92 **Exposure Height:** 170 cm **Exposure Type:** Auger Hole
Location: On west side of Saco, sw of Maietta Pit, 30 m from the river and 3-4 m above the river
Sediment Type: Sand **Comments:**

Unit	medium to fine sand			
Thickness	170 + cm			
Size	2.0			
Sed. Structures				
Current Dir				
Comments				

Site #: 137 **Date:** 7/20/92 **Exposure Height:** 75 cm **Exposure Type:** Auger Hole
Location: On high terrace west of road running along west side of Saco River
Sediment Type: Sand + Gravel **Comments:** terrace-like feature

Unit	sand and gravel			
Thickness	75+ cm			
Size	2.0			
Sed. Structures				
Current Dir				
Comments				

Site #: 138 **Date:** 7/20/97 **Exposure Height:** 60 cm **Exposure Type:** Auger Hole
Location: On high terrace west of road running along west side of Saco River
Sediment Type: Sand + Gravel **Comments:**

Unit	Pebble sand			
Thickness	60+ cm			
Size				
Sed. Structures				
Current Dir				
Comments				

Site #: 151 **Date:** 7/30/92 **Exposure Height:** 150 cm **Exposure Type:** Auger Hole
Location: At confluence of Ossipee and Saco Rivers
Sediment Type: Sand **Comments:** appears to be deltaic

Unit	sand			
Thickness	150+ cm			
Size	2.0			
Sed. Structures				
Current Dir				
Comments	well-defined bedding even in auger. alternating coarse-fine			

Site #: 152 **Date:** 7/30/92 **Exposure Height:** 20 cm **Exposure Type:** Auger Hole
Location: On top of flat- topped feature upslope from site 151
Sediment Type: Gravel **Comments:** topset beds of delta

Unit	Gravel			
Thickness	20+ cm			
Size				
Sed. Structures				
Current Dir				
Comments				

Site #: 159 **Date:** 8/2/92 **Exposure Height:** 140 cm **Exposure Type:** Auger Hole
Location: Halfway between railroad tracks and road SE of Cornish Station
Sediment Type: Sand **Comments:** Medium sand on top of till. Only thin veneer of sand at this location

Unit	sand	till		
Thickness	140 cm	--		
Size	1.5			
Sed. Structures				
Current Dir				
Comments				

APPENDIX 2: LOGS OF FIELD OBSERVATIONS - William R. Holland

See surficial materials map of the Cornish quadrangle (Newton, 1998) for site locations.

Pit #: C-1 **Date:** 7/5/83 **Exposure Height:** 20 ft

Location: Town pit off Rt 117, W of Saco, Cornish.
Sediment Type: Med-crse pebbly sand.
Landform: 350 ft valley train terrace.
Stratigraphy: Fluvially bedded sands and gravels.
Bedforms: On the scale of 3-5 ft there are deltaic-type sets: tangential "foresets"& "bottomsets".
Paleocurrents: Ave = S11W - S5E. Some up to S85E.
Environment of Deposition: Appear to be braid bars. Proglacial fluvial.
Structures: None seen.
Dominant Cobble Lithology: Granite, Ammonusuc, Moat.

Pit #: C-2 **Date:** 7/27/83 **Exposure Height:** 15 ft

Location: [Off Rt 117, .25 mi W of Limington town line]
Sediment Type: s,p,c-b
Landform: Hummocky ice-contact terrace 340 ft terrace.
Stratigraphy: Poor exposure. Sand with pbl gravel and cobble to boulder gravel. Surface of the deposit does not have the boulders that the 480 ft till/hummocky topo has.
Bedforms: No bedforms seen.
Paleocurrents: None measured.
Environment of Deposition: Ice-contact, marginal.
Structures: None seen.
Dominant Cobble Lithology: Granite, schist, volcanics

Pit #: C-3 **Date:** 8/4/83 **Exposure Height:** 10 ft

Location: Off woods road, 0.5 mi from Limington town line.
Sediment Type: s,p,c,b
Landform: 520 ft terrace
Stratigraphy: 6 ft cobble gravel, minor boulders/ 4 ft sand.
Bedforms: Sand appears massive, but gravels are imbricated.
Paleocurrents: Gravels imbricated current ~S50E.
Environment of Deposition: Appears to be deltaic (?).
Structures: None seen.
Dominant Cobble Lithology: Granite, schist, volcanics.

Pit #: C-4 **Date:** 7/5/83 **Exposure Height:** ~30 ft

Location: SE of Smalls Hill, W of Pease Brook, Cornish.
Sediment Type: Light brown to buff silty sandy gravel - gravelly sand.
Landform: Drift-tail - distal end of rock-cored drumlin.
Stratigraphy: Slumped ablation till. Minor stratified units present, ~3-4 in thick. Bouldery - poorly sorted. Fabric appears to be random, but no measurements taken.
Bedforms: Fine-med sand: planar, wavy, subhorizontal beds.
Paleocurrents: None measured.
Environment of Deposition: Subglacial probably near the ice margin.
Structures: None seen.
Dominant Cobble Lithology: Nearly 100% granites.

Pit #: C-6 **Date:** 7/11/83 **Exposure Height:** 13 ft

Location: Off unpaved road N of Rt 25, Limington (near 424 BM).
Sediment Type: p-c,s. Moderately well sorted. Small boulders.
Landform: Esker segment trends S30E.
Stratigraphy: Only 2 ft freshly exposed. Materials too coarse to see any stratigraphy. Appears to be uniform, based on scree character.
Bedforms: None observed.
Paleocurrents: None measured.
Environment of Deposition: Ice contact, but because of good sorting, may not have been in an ice tunnel.
Structures: None seen.
Dominant Cobble Lithology: Granite. Smaller stones: schist and volcanics.

Pit #: C-7 **Date:** 7/11/83 **Exposure Height:** ~18 ft

Location: Off Douglas Rd, near junction with Rt 117 Limington.
Sediment Type: s,p,c,b
Landform: Esker segment. Very low relief.
Stratigraphy: Entirely slumped. No data obtained.
Bedforms: Gravel imbricated. Stones are angular to subangular, have "glacial" shapes.
Paleocurrents: Imbrication of stones ~N10E.
Environment of Deposition: Ice contact, englacial. Very close to the source.
Structures: None observed.
Dominant Cobble Lithology: Granite, schist, volcanics.

Pit #: C-8 **Date:** 7/11/83 **Exposure Height:** 7 ft

Location: S side of Douglas Rd. near Rt 117.
Sediment Type: p-c,s
Landform: Kame terrace, kame plateau (~460 ft).
Stratigraphy: Poor exposure. No data.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Ice-contact. Stones have "glacial" shapes.
Structures: None seen.
Dominant Cobble Lithology: Granite, Ammonusuc Formation.

Pit #: C-9 **Date:** 7/11/83 **Exposure Height:** 9 ft

Location: McKinney's "gee-gaw" farm, Rt 25.
Sediment Type: s,p. Mostly sand. Very well sorted.
Landform: Elongate ridge ~N25W sep. from lower terrace.
Stratigraphy: Interbedded medium to coarse slightly pebbly sands.
Bedforms: Planar sets dip gently to the N.
Paleocurrents: N?
Environment of Deposition: Crevasse-filling? Appears too fine-grained to be englacial. Morph. may be erosional.
Structures: None observed.
Dominant Cobble Lithology: NA

Pit #: C-10 **Date:** 7/11/83 **Exposure Height:** 16 ft

Location: N of Rt 117, SE of Drive-in, NE of Smalls Hill.
Sediment Type: Sand with minor pebbles, Very well sorted
Landform: Valley train terrace.
Stratigraphy: Interbedded medium to coarse sands and fine-medium sands/ fine-medium sands.
Bedforms: Planar, sub-horizontal sets, Slight dip to ESE.
Paleocurrents: ~S80E
Environment of Deposition: Proglacial, fluvial or very shallow lacustrine.
Structures: None seen.
Dominant Cobble Lithology: NA

Pit #: C-11 **Date:** 7/11/83 **Exposure Height:** 24 ft

Location: Cornish Center, in back of Cornish Hardware.
Sediment Type: s,p
Landform: Valley train terrace.
Stratigraphy: All slumped.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Presumably proglacial fluvial.
Structures: None seen.
Dominant Cobble Lithology: NA

Pit #: C-12 **Date:** 7/11/83 **Exposure Height:** ~40 ft

Location: Near C-11.
Sediment Type: s,st,cy,p
Landform: Proglacial terrace - perhaps delta
Stratigraphy: This is part of Cornish terrace. Perhaps outwash/lake bottom rather than true deltaic. The man who owns pit says that he hit "marl" in C-11 as well, same el. as here. 6 ft yel br gravelly sd/ 8 ft lt br sl gr med sd, foreset dips/ 8 ft interbedded f sd, st & med sd, tabular, rollups/ 9 ft interbedded sty sd-sdy st, graded & rev grd/ varves, st & cy st.
Bedforms: Varves are 1.5 in thick, regardless of grain size
Paleocurrents:
Environment of Deposition:
Structures:
Dominant Cobble Lithology:

Pit #: C-13 **Date:** 7/11/83 **Exposure Height:** ~13 ft

Location: [.25 mi E of Rt 5, SW of Pease Mtn.]
Sediment Type: s,p,c. One boulder 2 ft diameter.
Landform: Pitted terrace.
Stratigraphy: 4 ft yellowish brown gravelly silty sand diamicton (could be plow zone)/ interbedded med-crse sands. Floor of pit is fine-med slightly pbly sand.
Bedforms: Trough x-sets. Some cut and fill: gravelly sand into med sand.
Paleocurrents: N23W, N46W, S23E, S13W
Environment of Deposition: Proglacial fluvial.
Structures: High angle reverse and normal faulting.
Dominant Cobble Lithology: Almost 100% granite.

Pit #: C-14 **Date:** 7/11/83 **Exposure Height:** 13 ft

Location: Near Day Cemetery, East of Long Pond.
Sediment Type: s,p
Landform: Hummocky but gen. flat-topped delta.
Stratigraphy: 1.6 ft horizontally bedded sandy pebble-cobble gravel/ 11.4 ft fine to medium sand, dipping at angle of repose.
Bedforms: Trough x-sets and foresets.
Paleocurrents: Foresets dipping to N64W.
Environment of Deposition: Shallow glaciolacustrine.
Structures: None seen.
Dominant Cobble Lithology: Chiefly granite.

Pit #: C-15 **Date:** 7/11/83 **Exposure Height:** 18 ft

Location: Just SE of Long Pond.
Sediment Type: p,s,c-b
Landform: Pitted outwash terrace.
Stratigraphy: 3.5 ft coarse cobble gravel/ 3 ft fine p-c gr/ 5 ft crse boulder gravel/slump.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Proglacial, fluvial.
Structures: None seen.
Dominant Cobble Lithology: Chiefly granites with minor schist.

Pit #: C-16 **Date:** 7/12/83 **Exposure Height:** 3 ft

Location: Edge of woods, W of Rt 25
Sediment Type: Medium-coarse sand, slightly pebbly.
Landform: Lower terrace. A higher one exists here.
Stratigraphy: All sand.
Bedforms: Massive.
Paleocurrents: None measured.
Environment of Deposition: Presumably proglacial fluvial (?).
Structures: None seen.
Dominant Cobble Lithology: NA

Pit #: C-17 **Date:** 7/12/83 **Exposure Height:** 7 ft

Location: In back of Drive-in Rt 25.
Sediment Type: s,p,c,b
Landform: Slightly higher terrace than at C-16.
Stratigraphy: Not exposed. Pit grown over. Unit is on grade with upper surface at C-16. Coarser deposit also suggests earlier age here.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Presumably early outwash or ice contact fluvial.
Structures: None seen.
Dominant Cobble Lithology: NA

Pit #: C-19 **Date:** 7/12/83 **Exposure Height:** ~35 ft

Location: N of Kezar Falls - S. Hiram Rd, Hiram town(?) pit.
Sediment Type: s,p,c
Landform: Valley train terrace.
Stratigraphy: 4 ft pebbly sand/ 14 ft pebble-cobble gravel/ slump.
Bedforms: Fluvial trough x-sets, up to 3 ft thick.
Paleocurrents: Gravels imbricated ~S50E.
Environment of Deposition: Proglacial fluvial. May be deltaic at depth..
Structures: None seen.
Dominant Cobble Lithology: Chiefly granitic rocks.

Pit #: C-20 **Date:** 7/12/83 **Exposure Height:** 15 ft

Location: Near jct Kezar Falls - South Hiram Rd and Wadsworth Bk.
Sediment Type: s,p,c
Landform: Valley train terrace.
Stratigraphy: 4 ft pebbly sand/ 11 ft cobble gravel. Throughout most of pit, units are separated by erosional unconformity, but at W end of pit, they interfinger.
Bedforms: Sands troughed, gravels planar and horizontal.
Paleocurrents: Gravel imbricated ~S78E.
Environment of Deposition: The sand may or may not be river terrace material. Units below are proglacial fluvial.
Structures: None seen.
Dominant Cobble Lithology: Chiefly granitic rocks.

Pit #: C-21 **Date:** 7/12/83 **Exposure Height:** ~10 ft

Location: [Near jct of S. Hiram Rd - New Settlement Rd]
Sediment Type: s,p
Landform: Terrace.
Stratigraphy: Appears to be uniform sand, pebble and cobble gravels. Poor exposure.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Presumably proglacial fluvial.
Structures: None seen.
Dominant Cobble Lithology: Insufficient sample. No data.

Pit #: C-22 **Date:** 7/12/83 **Exposure Height:** 14 ft

Location: Off River Rd, east of Saco, south of Hiram Falls
Sediment Type: s,p,c
Landform: Pitted outwash terrace.
Stratigraphy: Appears to be uniform.
Bedforms: Tabular, planar, upper flow regime. Beds now inclined, but dip likely due to collapse.
Paleocurrents: None measured.
Environment of Deposition: Proglacial, fluvial.
Structures: Dip on beds presumed due to collapse.
Dominant Cobble Lithology: Chiefly granitic rocks.

Pit #: C-23 **Date:** 7/15/83 **Exposure Height:** ~19 ft

Location: North of Rt 25, west of Fairgrounds in Cornish
Sediment Type: ps,c
Landform: 375 ft terrace.
Stratigraphy: Uniform pebbly sand to cobble gravel. New exposure slumped, could not get a fresh face.
Bedforms: None observed.
Paleocurrents: None measured.
Environment of Deposition: Presumably fluvial. May be topsets.
Structures: None seen.
Dominant Cobble Lithology: Granite, Littleton, Moat volcanics.

Pit #: C-24 **Date:** 7/15/83 **Exposure Height:** ~14 ft

Location: 0.5 mi W of C-23 off Rt 25.
Sediment Type: Med-coarse ps,p,c. Not as coarse as C-23.
Landform: 375 ft terrace.
Stratigraphy: Uniform stratigraphy.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Presumably fluvial (topsets?).
Structures: None seen.
Dominant Cobble Lithology: Granite, Littleton, Moat.

Pit #: C-25 **Date:** 7/23/83 **Exposure Height:** 8 ft

Location: South of Cotton Cemetery, North of Mt Misery, NE of Merrill Mt
Sediment Type: s,p
Landform: Kame complex.
Stratigraphy: 2 ft pebble gravel/ 3 ft pebbly sand/ 3 ft sand.
Bedforms: Planar sand beds (foreset-like).
Paleocurrents: Sands: 13 S83E.
Environment of Deposition: Ice marginal (?).
Structures: None seen.
Dominant Cobble Lithology: NA

Pit #: C-26 **Date:** 8/4/83 **Exposure Height:** 18 ft

Location: Rd parallel to Rt 113, SE of Ingalls Pond.
Sediment Type: c,pcs,b
Landform: 400 ft terrace
Stratigraphy: Uniform cobble gravels; exposure poor.
Bedforms: None seen.
Paleocurrents: None measured.
Environment of Deposition: Presumably fluvial(?).
Structures: None seen.
Dominant Cobble Lithology: Granite, volcanics.

Pit #: C-27 **Date:** 8/4/83 **Exposure Height:** 11 ft

Location: Off Rt 113, E of Hiram Falls.
Sediment Type: s,p, minor c.
Landform: 400 ft terrace.
Stratigraphy: Fluvially bedded sands and pebble gravels.
Bedforms: Braid bars, cut and fill.
Paleocurrents: Generally southerly.
Environment of Deposition: Fluvial.
Structures: None seen.
Dominant Cobble Lithology: NA

Pit #: C-28 **Date:** 8/17/83 **Exposure Height:** 22 ft (including upper pit)

Location: Este's pit, NE of Rt 113 Baldwin.
Sediment Type: c-b/t
Landform: Valley train (Breakneck Brk deposits).
Stratigraphy: N side of pit: 3 ft p-c w/ occ large bldr/ 1.5 ft plane bdd pby sd/ till (ablation). At top of till is a bldr lag. E side: 5 ft c-b/ 2 ft m-crs pby sd.
Bedforms: All bedforms planar, horiz. Pseudo foresets in sand, 7 in thick. Poor gravel imbrication.
Paleocurrents: Gravel imb: ~S23E and ~N80W; "foresets": 19 S42W.
Environment of Deposition: Deposit seems to get finer to SW. Appears to be a fan. Scarp to W indic. predates Saco dep..
Structures: W/ possible exception of small kettles, NA.
Dominant Cobble Lithology: Granite, volcanic, schist.

Pit #: C-30 **Date:** 8/25/83 **Exposure Height:** ~80-100 ft from top of bank to river.

Location: Hiram Falls Dam
Sediment Type: s,st,t,rk
Landform: 400 ft outwash delta.
Stratigraphy: ~7 ft pebbly sand/ ~10ft medium sand/ ~5-30 ft fine laminated silty sand to sandy silt/ 0-2 ft ablation till/ rk..
Bedforms: Pbly sd: horizontally bdd (fluv); Sd: dips 14 S25E with type B ripple-drift; Sdy st: wavy lam., rollups.
Paleocurrents: S25E.
Environment of Deposition: Distal prodelta slope (?) Subaqueous deposition.
Structures: Diapirs, rollups and other dewatering features.
Dominant Cobble Lithology: Amphibolitic gneiss (local rk).
