Glacial Features within the Nissequogue River and Connetquot State Park area

Dylan Duprez and Gilbert Hanson
Department of Geosciences at Stony Brook University
Stony Brook NY

Introduction

Long Island contains a plethora of geology due to the various features that the glaciers left behind as a result of the last glaciation during the Pleistocene Epoch. Around 21,000 years ago, the Laurentide Ice Sheet extended south from Connecticut to Long Island at the Last Glacial Maximum (Lewis, 1995). During the Last Glacial Maximum the sea level was 125 meters lower than the current sea level (Fairbanks, 1989) and the shoreline was 50-70 miles southeast of its current position (Lewis, 1995). As the glacier moved over Long Island, it deposited sediment over the Cretaceous sediments and thrust the underlying Cretaceous and glacial sediments into the glaciotectonic Harbor Hill and Ronkonkoma moraines, it also transported boulders dragged from the bedrock of Connecticut and what is now the Long Island Sound (Pacholik, n.d.). The glacier advanced and retreated multiple times during the last glaciation, extending to a southern maximum of the Ronkonkoma Moraine, but also leaving behind the Harbor Hill moraine approximately 7 km north of it. (Lewis, 1995) The Ronkonkoma moraine is thought to be the glacial maximum, but there has been some debate given evidence for a potential third moraine that cannot be seen because it extended into the current continental shelf of the Atlantic. If this moraine did exist, it would not be visible today because of erosion. (King et al, n.d.) You can find King et al at http://www.geo.sunysb.edu/lig/Conferences/abstracts-03/4-03-program.htm.

Predating the glacial material on Long Island is a distinct layer of clay that has been named Gardiners Clay. This clay is identified primarily by the fossil content within it and is greenish-grey, but can be other colors as well. There is no evidence for other fossiliferous interglacial clays, so any clay that contains fossils and is overlain by glacial material is considered Gardiners Clay (Weiss, 1954). The assembly of fossils in Eastern Long Island clays suggests that the depositional environment was a shallow marine body of water that was brackish, similar to some of the bays we have today. Though fossils are helpful in determining these features, the fossil content is variable and the lithology can be quite different as well, suggesting that deposition was not uniform in the area (Weiss, 1954). The Gardiners clay is older than 38,000 years based on carbon-14 testing of oyster shells (Doriski, 1983). Given the position of identified Gardiners clay and the carbon-14 age, it is thought to be deposited during the Sangamon Interglacial.

Northern clays have been grouped separately into the North Shore Confining Unit (NSCU) as opposed to using the name Gardiners Clay due to questionable correlations (Stumm, 2001). NSCU clays fit into two separate sequences, one similar to the Gardiners Clay that was shallow and brackish and another that was caused by a proglacial freshwater lake. The brackish marine setting is inferred by the presence of oyster shells in grey-green clay that date back to 225,000 years of age (Strumm, 2001). Underlying this older sequence is usually cretaceous sediment which indicates that it is either in place or was transported by the ice. The other sequence contains no shells, is varved, and does not always overlie Cretaceous material, which suggests a younger proglacial lake setting (Strumm, 2001). Given the proglacial lake depositional setting for the younger clays, many of the low lying basins and erosional features created by the glacier are filled in with these clays. (Strumm, 2001)

A Digital elevation model created by Dr. Gilbert N. Hanson reveals depressed features within the area from the Nissequogue River to Connetquot State Park, including what looks like a tunnel valley (shown in orange), a large circular depression that the tunnel valley connects to (shown in red), and a break in the Ronkonkoma Moraine that leads into a channel (shown in yellow) in Fig. 1 (Hanson, 2015). A tunnel valley is caused by meltwater that is pooled under a glacier and expelled forcefully with a high hydraulic head. When the water is released, it forces its way out of the glacier to the ice margin and is ejected with a very large amount of energy. This can result in deeply cut valleys in sediment under the glacier with undulating profiles. Tunnel valleys run towards the ice margin and can potentially flow uphill due to the large hydraulic head (Kehew et al, 2012). This can be seen in figure 3, where the potentiometric surface is uphill of where the water is pooling, causing the meltwater to move vertically to the toe of the glacier. Tunnel valleys may be up to 400m in depth and several km wide often with valley walls (Kehew et al, 2012). The high energy outbursts not only create these long “U” shaped depressions, but can be responsible for canyon like structures within the glacier where water is pooling (Martini, 2001) The process of tunnel valley formation is thought to have been much more likely in the later Pleistocene given the gradual accumulation of fine-grained deposits and tills at the base of the glacier. These deposits tend to be less permeable, leading to less drainage of any subglacial lakes that formed from meltwater (Kehew et al, 2012). When subglacial lakes accumulate, the basal fluid pressure increases and a catastrophic drainage event is more likely to occur (Kehew et al, 2012).

Given the shape of the depression in the DEM, it appears that a tunnel valley could be present from the mouth of the Nissequogue River leading into the large, bowl shaped area (Figure 1). This rounded depression may have been a canyon created during an advance as another tunnel valley potentially carved through the Ronkonkoma Moraine (Hanson, 2015). Figure 2 shows the area that could potentially be a tunnel valley and the gap in the Ronkonkoma Moraine. It would not be uncommon that the area spanning from the Nissequogue River to Connetquot was carved out by one or several tunnel valleys from the several advances and retreats of the glacier.

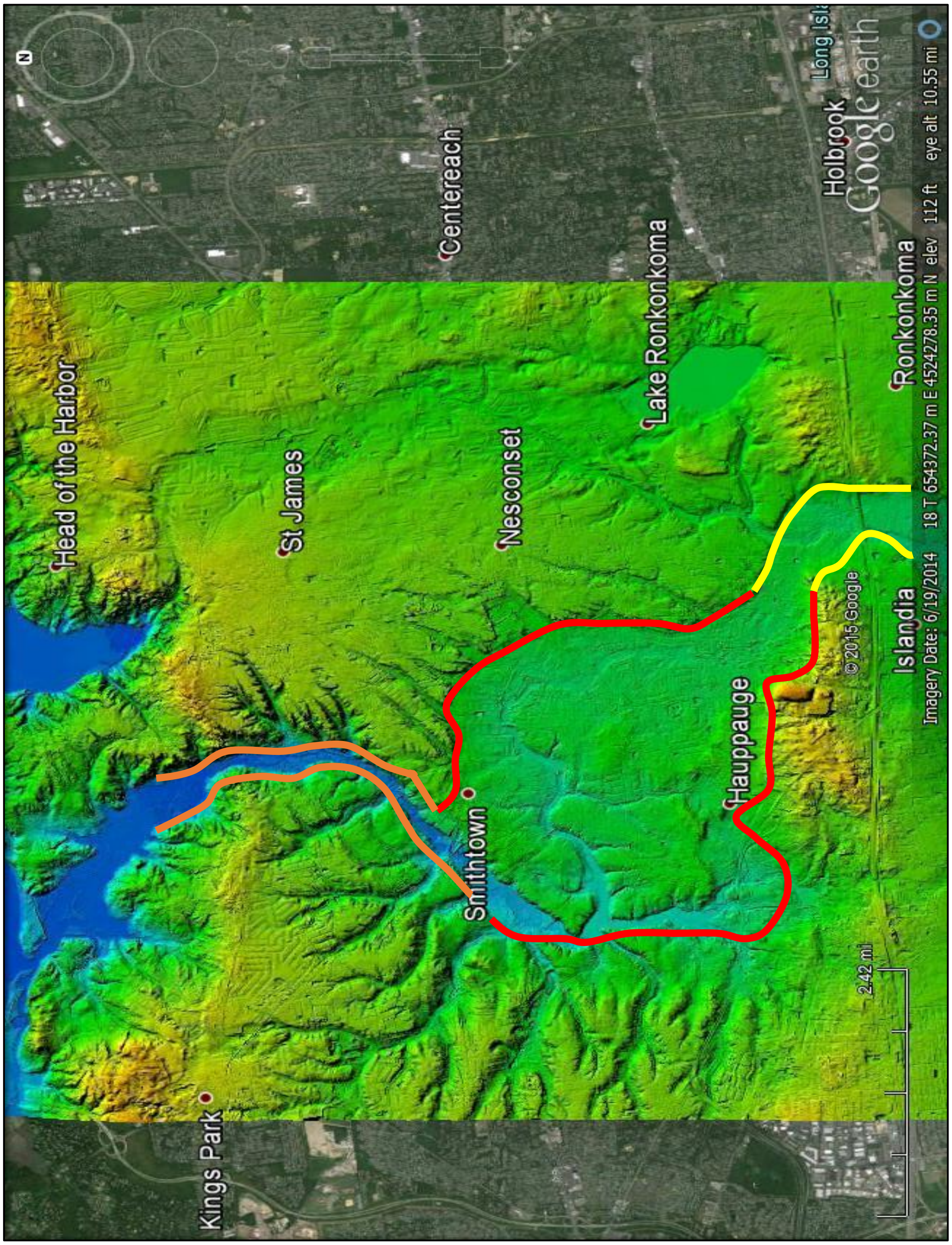

Figure 1- DEM of Nissequogue River, northern Long Island

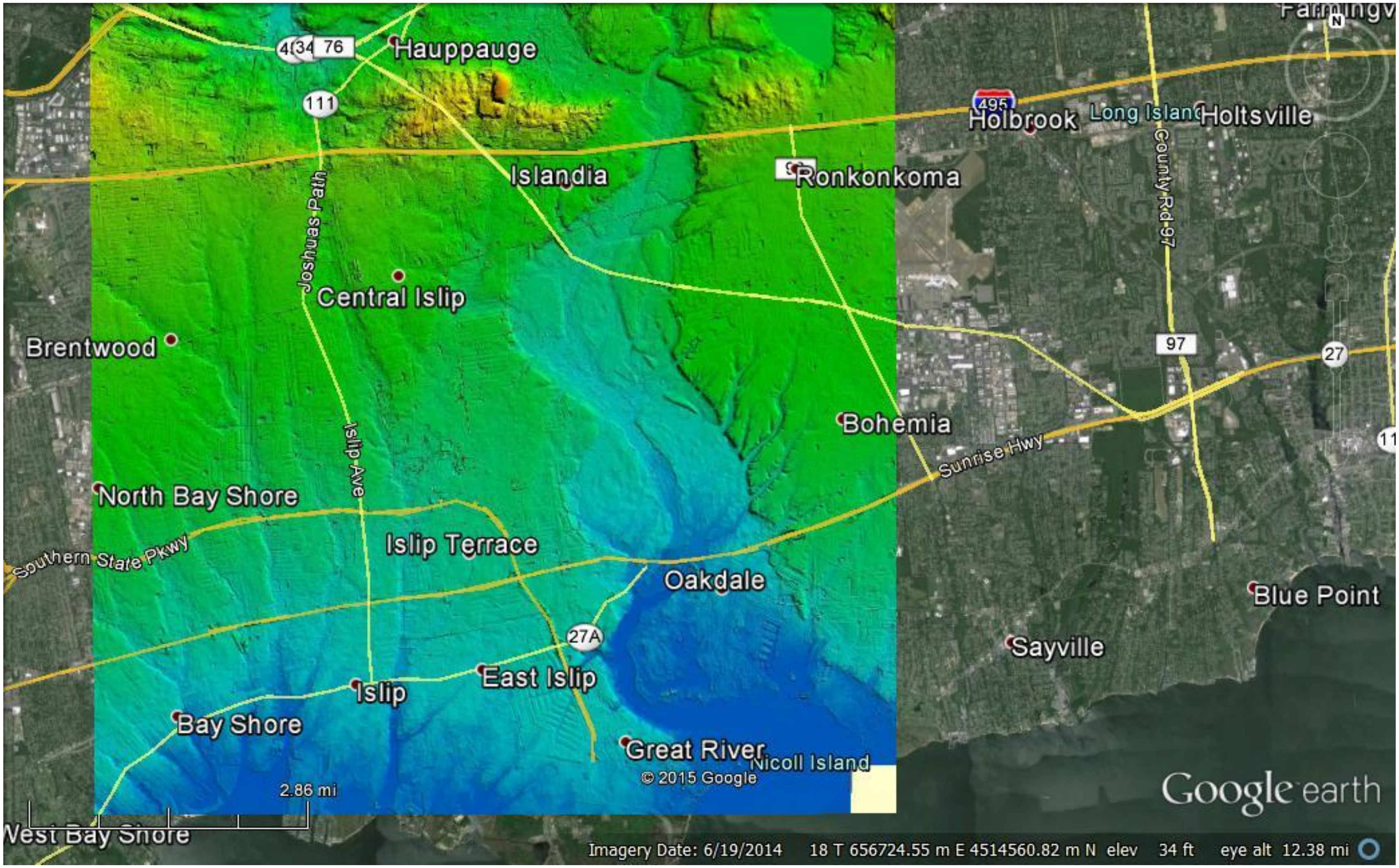

Figure 2- DEM of Connetquot region, Middle/Southern Long Island. Note the Ronkonkoma Moraine which is just north of Interstate 495 (Long Island Expressway)

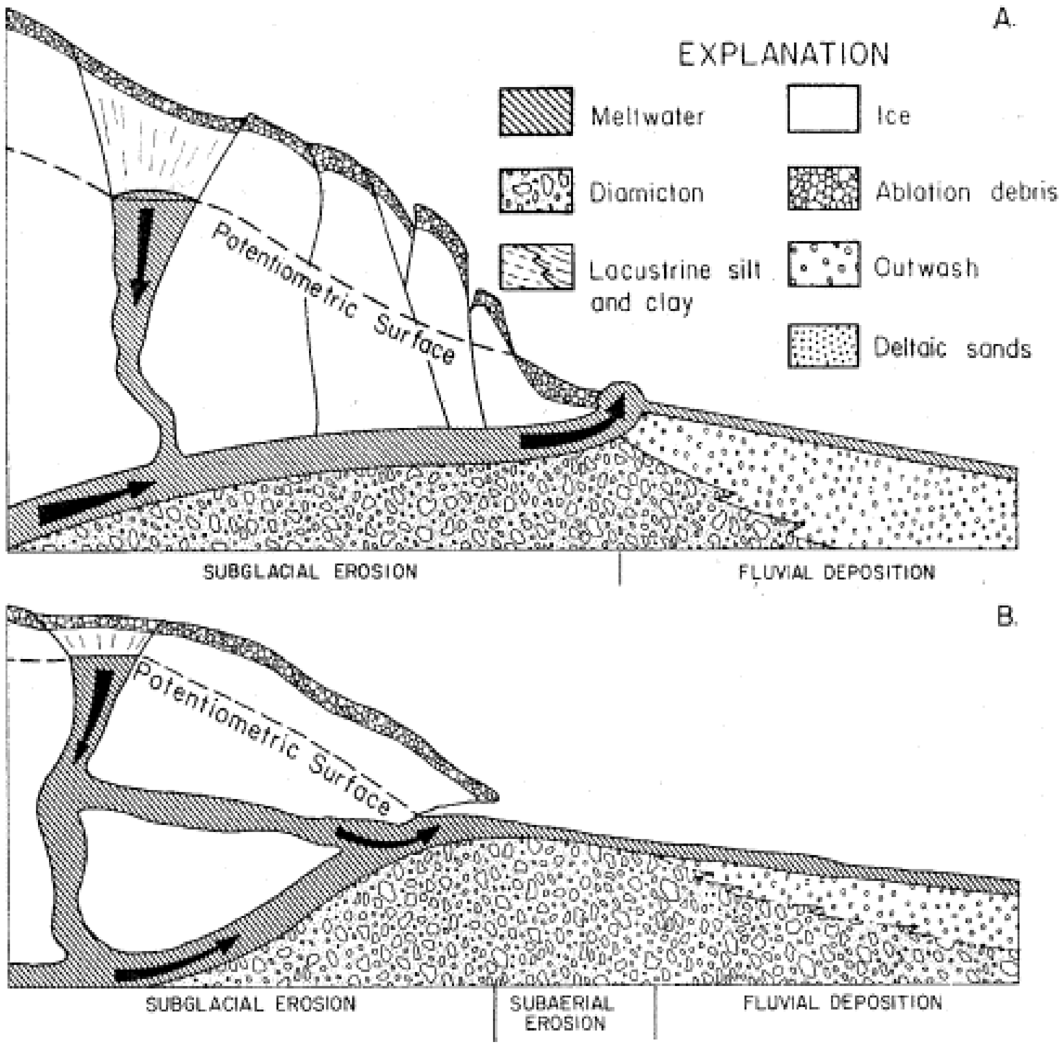

Figure 3- Glacial sediment deposition and meltwater movement due to internal pressure

Well logs in the area can be used to reveal the underlying strata and describe the depositional environment during the last glaciation. This information can also be used to describe the erosion that would have been caused by the tremendous energy of the sub-glacial streams forming tunnel valleys. Well logs of the subsurface stratigraphy provide a better understanding of the features that can be seen at the surface and possibly connect them to features present underneath them.

Buried tunnel valleys usually have till and glaciofluvial/glaciolacustrine material filling them (Martini, 2001). If a glacier is advancing, there is an upwards coarsening of sediments. This is due to the transportation of sediment by the glacier, which tends to be massive, unsorted, and unstratified and can be deposited due to strong meltwater stream fed from the glacial margin, lodgment under the sliding glacier, or melt-out from the base/within/top of the glacier (Martini, 2001). These sediments are usually composed of sandy, stony till that includes some clay. If a glacier is stagnant over an area, or when accumulation is equal to ablation, it will deposit till over time, leading to a deeper section of till in the observed section (Piotrowski, 1994). When a glacier is retreating there are more homogenous sediments that indicate a glaciofluvial (mostly sands and gravels) or a glaciolacustrine environment (fine sand, silt and clay) depending on how far the glacier is from the location (Krohn et al, 2009). Streams near the glacier will fluctuate in energy more than those distal due to the daily or seasonal variations in meltwater discharge causing strong variation in grain size (Martini, 2001). Streams farther from the glacier have less energy and carry finer sediment that those closer to the glacier. Streams of this nature will be dampened and have less fluctuation in grain size (Martini, 2001).

Multiple meltwater streams tend to intertwine as they flow into what are called braided streams. These streams deposit sediment differently among banks than in the channel, like other streams, but can shift quite a bit as they find the path of least resistance (Martini, 2001). As a braided stream is depositing large amounts of glacial sediment, the stream will change course and refill its previous path while cutting a new one (Martini, 2001). Due to these characteristics, outwash sequences contain many sedimentary features indicative of changing stream flow such as fining upwards patterns in fills, cross bedding, and laminations. These streams all eventually lead to lacustrine or marine delta environments where the energy is low enough to deposit the remaining fine sand and clays (Martini, 2001). If meltwater accumulates and is dammed by glacial ice it can form a proglacial lake if the surrounding topography does not allow drainage (Krohn et al, 2009). A Tunnel valley should therefore be filled with coarse material at its base given the energy of the event that forms this feature, overlain by a sandy/silty sediment which is relatively more distal, and then overlain by a unit that may not be directly influenced by the glacier, such as a clay layer deposited in a lacustrine setting (Janszen et al, 2012). This is the pattern seen in tunnel valley infill, but the thickness of the units is dependent on the speed of advance and recession of the glacier front.

Methodology

Well logs were obtained from the Suffolk County Water Authority and the United States Geological Survey and compiled to create four cross sections that run roughly West to East over the Nissequogue-Connetquot area. Global Mapper, a program produced by Blue Marble Geographic's (http://www.bluemarblegeo.com/products/global-mapper.php), was used to generate the topography of the surface in these cross sections. Using the sediment data from the wells in addition to a previously compiled Cretaceous depth map of Long Island for reference, the maximum depth of glacial material could be determined. This was done using sediment information from Smolensky et al (1989), which describes sediment colors and generalized sorting to differentiate between glacial and Cretaceous sediments. The depths to the upper Cretaceous sediments, the Magothy formation, were put into Excel to generate a rough topography of the Cretaceous surface from west to east. Using both the surface topography and Cretaceous boundary data, it was then possible to juxtapose them and observe matches in shape. The map showing the elevation of the top of the Cretaceous boundary can be seen in Figure 4. The well locations as well as the DEM were plotted on Google Earth. This provided the elevation data for the wells used to adjust the Pleistocene-Cretaceous boundary relative to sea level as well as surface elevation profiles for two North/South cross sections. The wells and cross sections 1-4 (West-East) can be seen in Figure 5. In this figure there are several wells that are not in the cross sections such as S-2426 and S-30729, which were not used due to their location outside of the area of interest. Data for well S-308 part of section 4 was not used due to poor data quality.

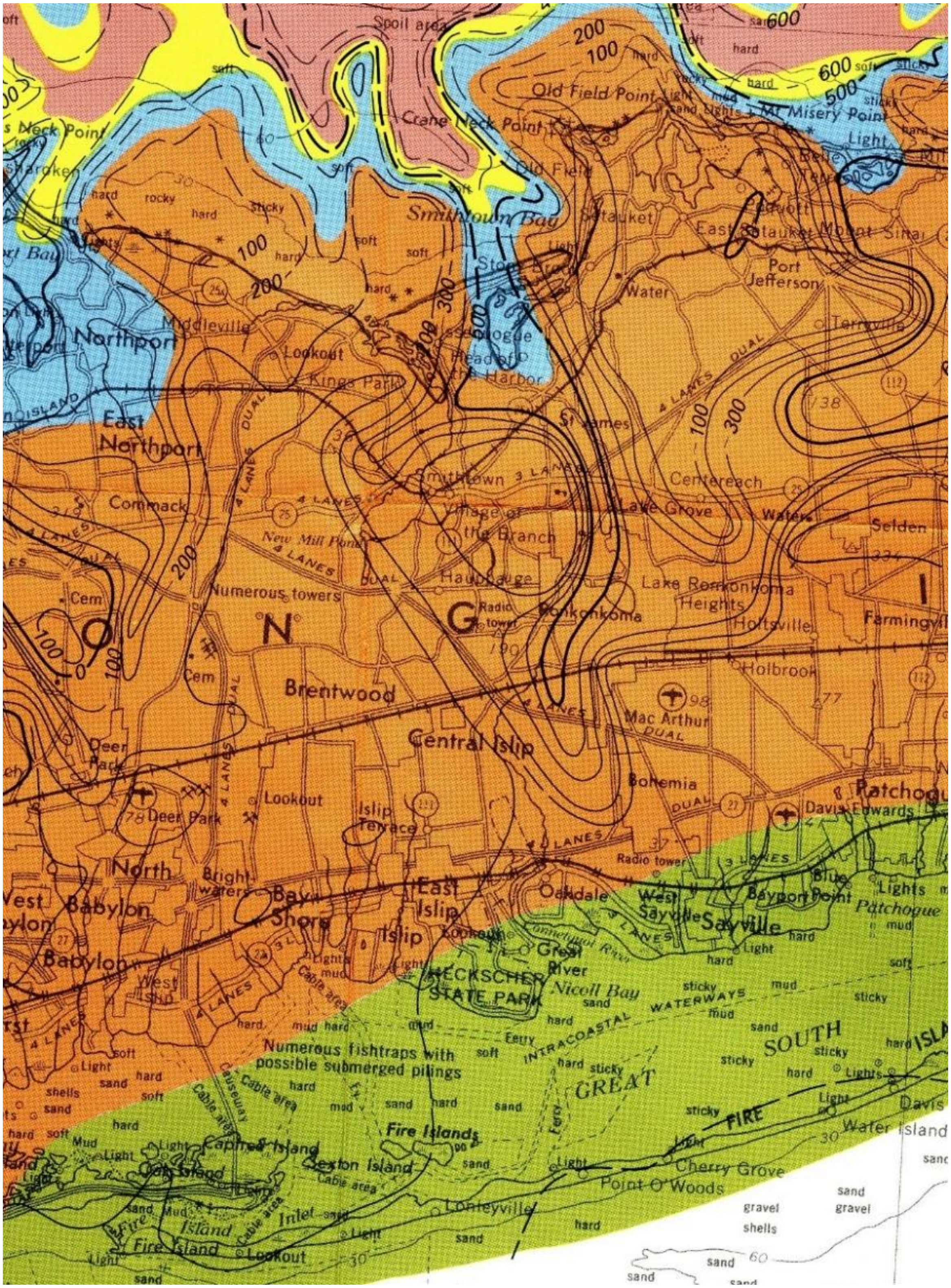

Figure 4- Map of topmost Cretaceous material (Smolensky et al, 1989)

Cross section 1 (figure 5), was created from four well logs (S-66155, S-66156, S-17181, S-98721) near Sunrise Highway. Cross Section 2 was created from four well logs (S-66153, S-73341, Unnamed well on Peconic Street, S-77842) located south of the Long Island Expressway, on the northern edge of Connetquot State Park. Cross Section 3 was created using three well logs (S-37276, S-38491, S-30118) and is located just north of the Long Island Expressway and the Ronkonkoma Moraine. Cross section 4 was created using five well logs (S-40711, S-308.1, S-39518, SM-935, unnamed well at Hallock Avenue) along Route 25A, over the Nissequogue river. Some of the well logs included the contacts between the Pleistocene and Cretaceous sediments, but many did not. Descriptions of Pleistocene and Cretaceous sediments from Smolensky et al (1989) and guidance from Professor Hanson were used to identify boundaries when none was provided (Smolensky et al, 1989).

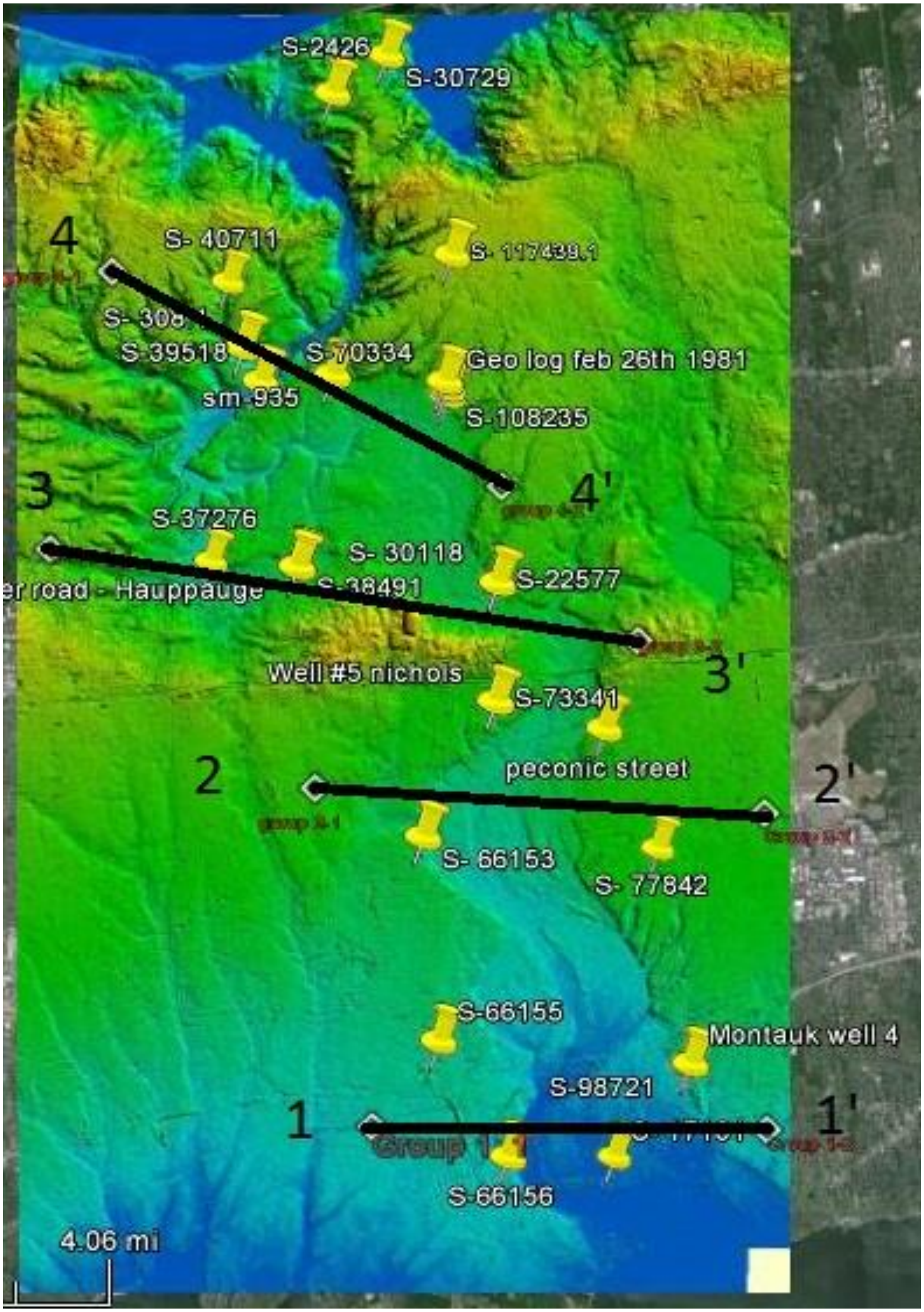

Figure 5- DEM and wells in the Nissequogue-Connetquot region.

Results

The well logs collected to define the Cretaceous/Pleistocene boundary were adequate, though some logs were not used due to limitations in data such as lack of color or oversimplification of strata. The boundaries found via interpretation from the well logs mostly matched well with those of Smolensky et al, (1989). In locations with multiple wells, such as Hallock Ave, most wells gave similar boundaries. Only the most descriptive wells that contained detailed strata with sediment color and grain size were used.

Well Log Data/Summary

Here the well logs are summarized and uncertainties in the data are addressed. The wells are listed starting with Cross Section 1 in west to east order. The Boundary between the Pleistocene and Cretaceous sediments as well as the depositional environment of Pleistocene sediment describe the glacial features so they will be the focus within the descriptions

Wells within Cross Section 1

S-66155: This well is located west of the channel shown in the DEM at the intersection of Heckscher State Parkway and Sunrise Highway. The Pleistocene-Cretaceous boundary is given by a geological interpretation at 88 feet below sea level. Lignite, an indicator of Cretaceous formations, is found below this depth. Clays are present from 71-88 feet below sea level and are blue to bluish-grey in color. These were identified in the log as part of the Gardiner's clay formation. Deposition in this region looks fluvial in origin due to well to semi-sorted fine to coarse sands and gravels in each separate unit.

S-66156: This well is located close to the shore of Nicoll Bay just east of Heckscher State Parkway. The Pleistocene-Cretaceous boundary is at a depth of 112 feet below sea level given by geological interpretation in the log. There is black color clay indicative of interglacial clay that overlies Cretaceous sediment. Clay found between 94 and 112 feet below sea level was identified as part of the Gardiners Clay in the log. The glacial Pleistocene sediment is fining upwards from 82 feet to 77 feet below sea level. From 77 feet to the surface the sediments are coarsening upwards.

S-17181: This well is located near the shore of Nicoll Bay, south of Sunrise Highway. It looks to be within the channel that is shown in the DEM. No geological interpretation was provided for this log. The Pleistocene-Cretaceous boundary was found at a depth of 194 feet below sea level, indicated by a layer of interglacial black clay that overlies Cretaceous sediment. The well consists of mostly sands and clays, but gravel is found within some sand layers. Deposition looks mostly fluvial and lacustrine in origin due to homogenous compositions of sand and the presence clays.

S-98721: This well is located east of the intersection of Oakdale-Bohemia Rd and Montauk Highway. There was no geological interpretation provided. The Pleistocene-Cretaceous boundary is located at 127 feet below sea level, indicated by a layer of dense black clay that overlies Cretaceous sediment. This well contains clays that are most likely part of the Gardiners clay and glacial Pleistocene material that contains sands, gravel, and stones. Deposition looks mostly fluvial in origin due to homogenous sediments. The Pleistocene sediments are overall coarsening upwards to surface.

Wells within Cross Section 2

S-66153: This well is located on the west side of the channel indicated in the DEM, just west of Connetquot Ave. Geological interpretation marks 68 feet below sea level as the Pleistocene-Cretaceous boundary. At this depth there are white clays, which are indicative of Cretaceous material. This well contains sands, clay, and gravel. In some units there are rock fragments. Deposition appears to be fluvial due to homogenous sediment. The sequence is upwards coarsening from 68 feet to 45 feet. Coarse material that consists of medium and coarse sand with gravel is constant for most of the remaining units to surface. Only the top 5 feet of sediment is composed of homogenous fine brown sand.

S-73341: This well is located close to the Ronkonkoma Moraine, just east of Old Nichols Rd. No geological interpretation was provided. The Pleistocene-Cretaceous boundary is at a depth of 160 feet below sea level, indicated by the presence of multicolored clay. Deposition looks to be fluvial and potentially ice-proximal in nature given the presence of till from 141 to 160 feet below sea level.

Peconic Street well: This well is located between Veterans memorial Highway and the Long Island expressway on the eastern side of the channel seen in the DEM. A geological interpretation is provided in this log, estimating the Pleistocene-Cretaceous boundary to be at a depth of 484, but a coarse red sand layer is found at 448 feet below sea level that is indicative of Cretaceous sediment. Deposition in this area is mostly fluvial and is in some cases ice-proximal. This well contains a few units of high energy, coarse sediment with some sorting which would indicate outwash, potentially from a tunnel valley given they contain large stones.

S-77842: This well is located south of Veterans Memorial Highway near Long Island MacArthur Airport. The log includes a geological interpretation which concluded that the Pleistocene-Cretaceous boundary was located at a depth of 405 feet below sea level, but above is not all glacial. At 240 feet below sea level there is glauconitic sand which is indicative of a marine environment and is typically not found in glacial material (Hanson, 2015). There is white sand found at 201 feet below sea level which indicates Cretaceous material. This will mark the Cretaceous boundary, even though a large gap exists in the surface depths. The sequence is fining upwards from the white sand.

Cross Section 3 Wells

S-37276: This well is located near Suffolk County Police Department along Veterans Memorial Highway. Geological interpretation states that it is all Pleistocene to 353 feet below sea level. This well log is limited in that it does not list the color(s) of sediments near the bottom of this well. Energy in this well fluctuates very frequently, most likely due to deposition in an outwash plain near the glacial margin.

S-38491: This well is located at the intersection of route 111 and Veterans Memorial Highway. A geological interpretation of the Pleistocene-Cretaceous boundary was provided, but was identified as incorrect by Dr. Hanson. The boundary is located at 112 feet below sea level which is due to the presence of a multicolor clay layer. The 203 foot depth provided by the log has a question mark written next to it and the 266 value has "Magothy" written without any other notation. The depositional environment was constantly changing in energy, most likely due to outwash streams near the glacial margin.

S-30118: This well is located North of Long Island Expressway and the Ronkonkoma Moraine just off of Terry Rd. There is a geological interpretation of the well in the log which labels all of the well sediments as being Pleistocene in origin. This well was drilled to 142 feet below sea level and contains mostly fluvial sediment that is the result of outwash streams given the rapid changes between fine and coarse homogenous sand layers. There are boulders present in coarse sand and gravel, which could be ice-proximal deposits.

Cross section 4 wells

S-40711: This well is located off of Route 25A on the western side of the Nissequogue River. There was no geological interpretation provided for this well. There appears to be no Cretaceous sediment present in this well, which goes down to a depth of 187 feet below sea level. Deposits are fluvial, lacustrine, and ice-proximal in origin.

S-39518: This well is located on the eastern side of the Nissequogue River, south of Route 25A. No geological interpretation was provided in the log. This well has a Pleistocene-Cretaceous boundary at a depth of 39 feet below sea level marked by a layer of white fine sand. The deposition of glacial material appears to be all ice-proximal; there is an abundance of gravel and coarse sand. There is a layer of clay that contains gravel, potentially from rain out. It may be due to a subglacial lake environment rather than an ice-distal setting.

SM-935: This well is located just on the edge of Smithtown, south of Route 25A. There was no geological interpretation provided in its log. The Pleistocene-Cretaceous boundary is located 206 feet below grade indicated by a layer that contains streaks of black clay. This well contains mostly clay and fine sand indicating a fluvial/lacustrine depositional environment. The sediment becomes much coarser at 67 feet below sea level compared to the other glacial stratum in the well. There is no data from 42 feet below sea level to surface depth.

Hallock Ave. Well: This well is located south of Route 25A and west of Terry Rd. There was no geological interpretation included in the log. The Pleistocene-Cretaceous boundary can be found at 218 feet below sea level indicated by pinkish colored clay. This well contains primarily clay, but there are some gravels and stones found in the deeper glacial material. The top of the well was labeled as top soil, but after visiting the site and looking at the top 2 or so feet, it was found to be composed of clay, very fine sand, and fine sand that contains pebbles. This layer was about 8 inches thick and followed by a layer that was nearly identical, but also contained cobbles.

Table 1: Depth of the Pleistocene-Cretaceous (PC) boundary relative to sea level so that the wells are comparable

Well #	Elevation above sea level (feet)	PC boundary below grade (feet)	PC boundary relative to sea level (feet)
S-66155	30	118	88
S- 66156	18	130	112
S-17181	3	197	194
S-98721	13	140	127
S-66153	50	118	68
S-73341	64	224	160
Peconic	66	514	448
S-77842	57	258	201
S-37276	46	399	353
S-38491	67	179	112
S-30118	55	*197	*142
S-40711	91	*278	*187
S-39518	60	99	39
SM-935	59	265	206
Hallock Ave	53	271	218

*at least this depth

Results of Cross Sections 1-4

Cross section 1: Well S-17181 differs from Smolensky et al (1989) estimates, giving a depth that ranges from 50 to 100 feet deeper. This range is due to lack of more precise data from Smolensky et al (1989). The map contains contours at every 50 feet, so smaller variations are unknown. Due to lack of precise data on the Smolensky map, which would cover the area between 100 to 150 feet, the data was not plotted in figure 6. When the plot of the well is compared to that of surface topography there is a similar depression in the middle (figure 7). In Figure 8 the composition of the wells can be seen. The only similarity seen between more than two wells is the blue/green silty clay that is found at the bottom of the glacial sediment and the coarse sandy layers near the top of S-66155, S-17181, and in the middle of S-98721.

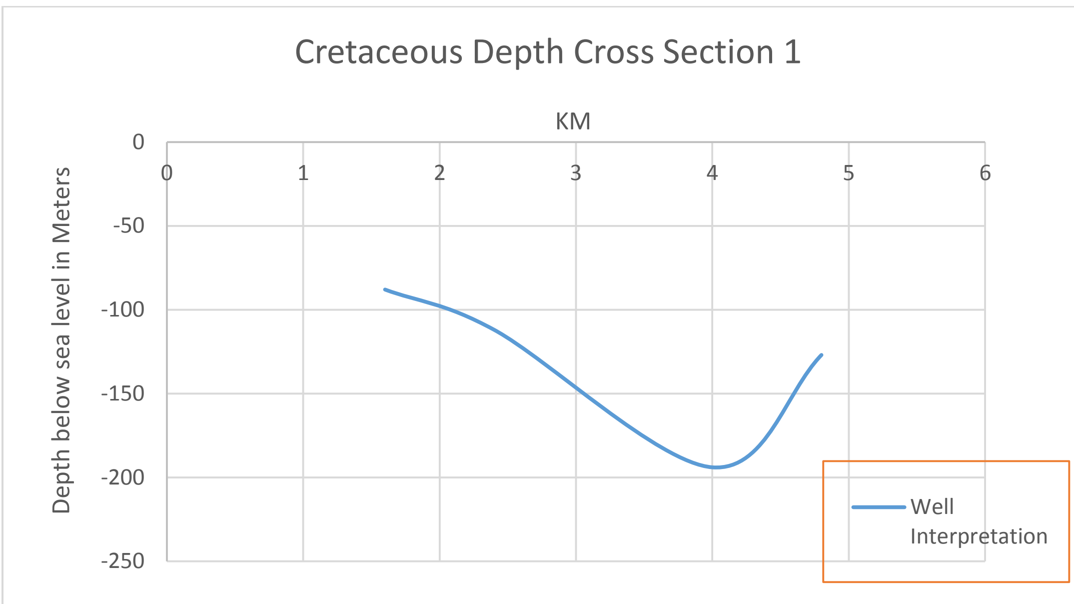

Figure 6- Shape of Cretaceous boundary on cross section 1 (from 1 to 1')

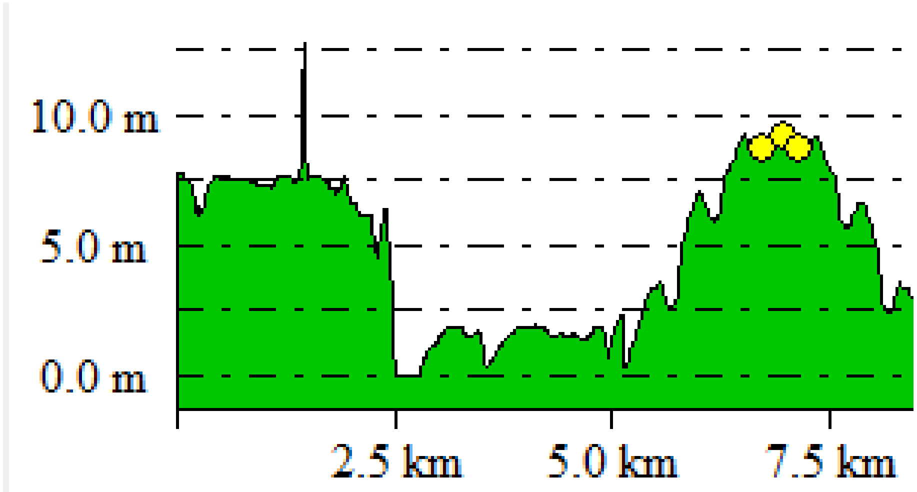

Figure 7- surface elevation from 1 to 1' created using Global Mapper

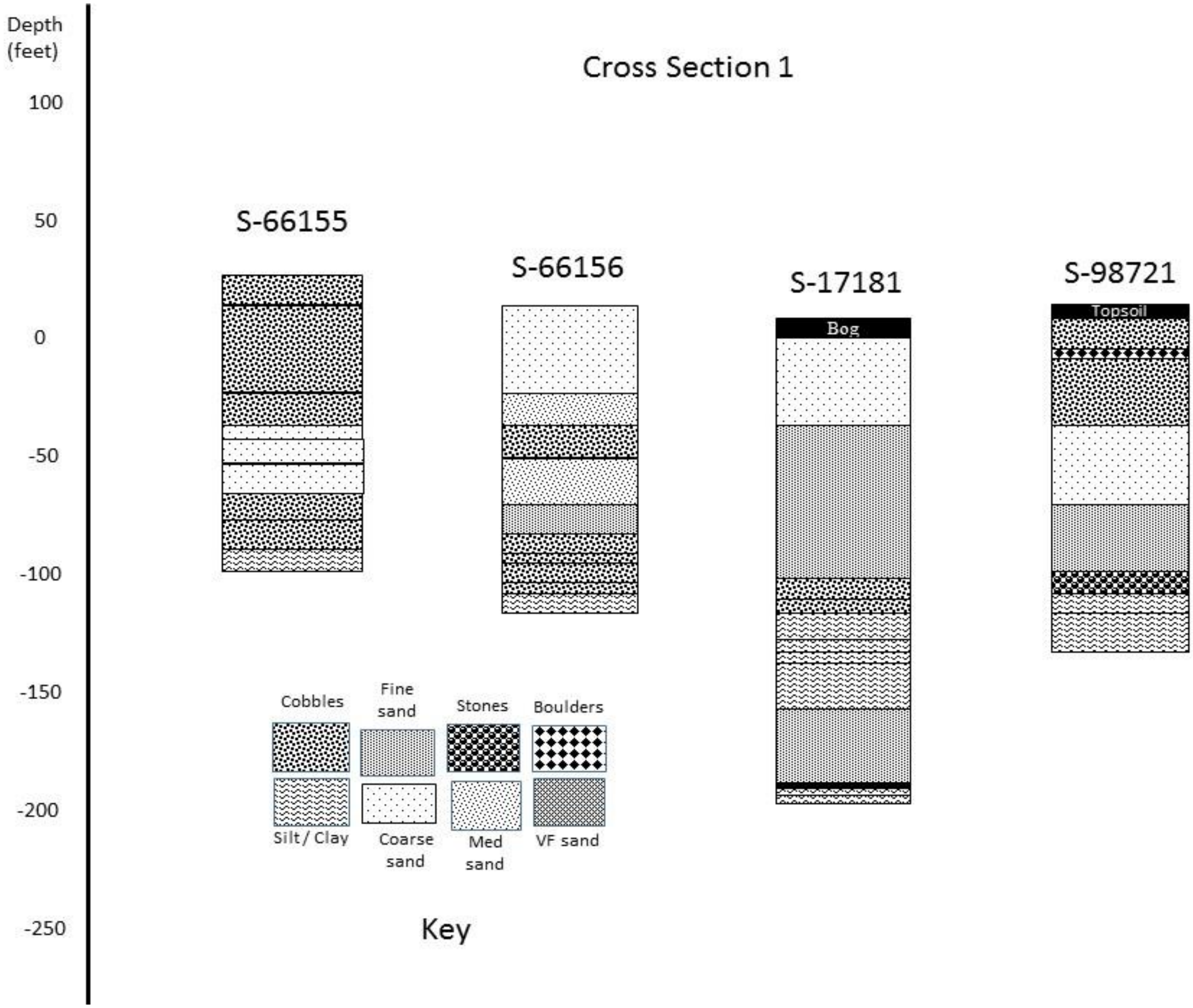

Figure 8- Strata of wells in cross section 1

Cross section 2: Most wells matched well with the Smolensky et al (1989) data as seen in Figure 9. Well S-77842 provided a similar estimate to that that of Smolensky. The surface topography matches well with the Upper Cretaceous boundary, as shown in figure 10. In figure 11, the strata once again do not match very well. The only similarities lie in the top 50 feet of sediment for S-66153, S-73341, and the Peconic well where there is coarse grained sand and cobbles seen in each. There is a large amount of green sediment in the east and southern most well (S-77842). The green sediment found just under 100 feet below sea level looks like it may belong to the Gardiners Clay formation, which is around the same elevation as the formation in the wells from cross section 1, but it is a distinct darker green and contains coarse material.

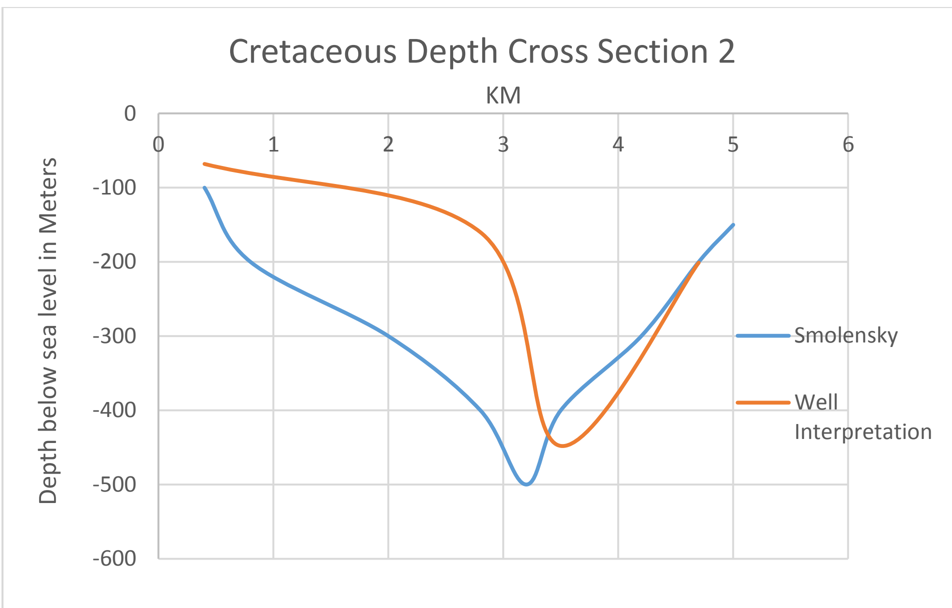

Figure 9: Shape of Cretaceous boundary over cross section 2 (from 2 to 2')

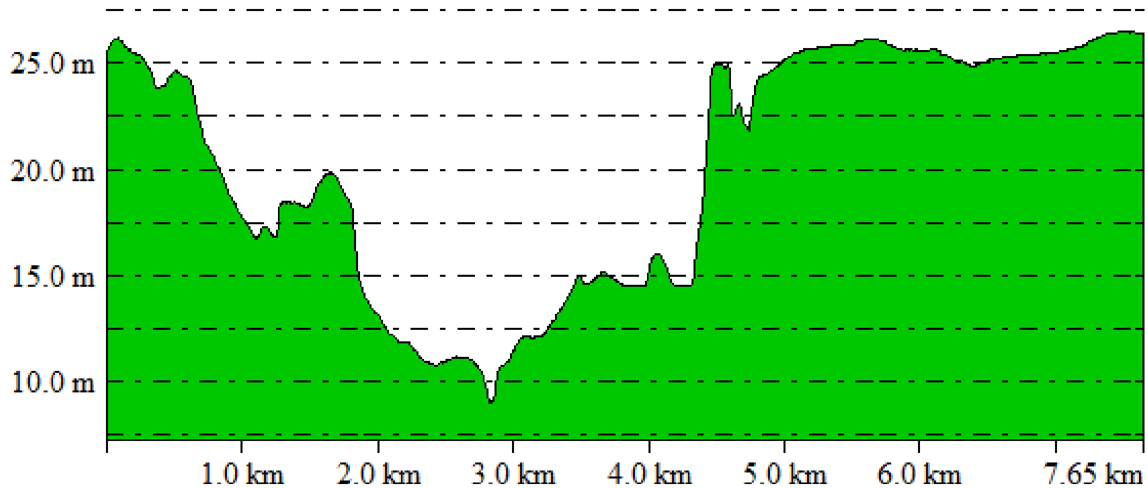

Figure 10: Surface elevation from 2 to 2’created using Global Mapper

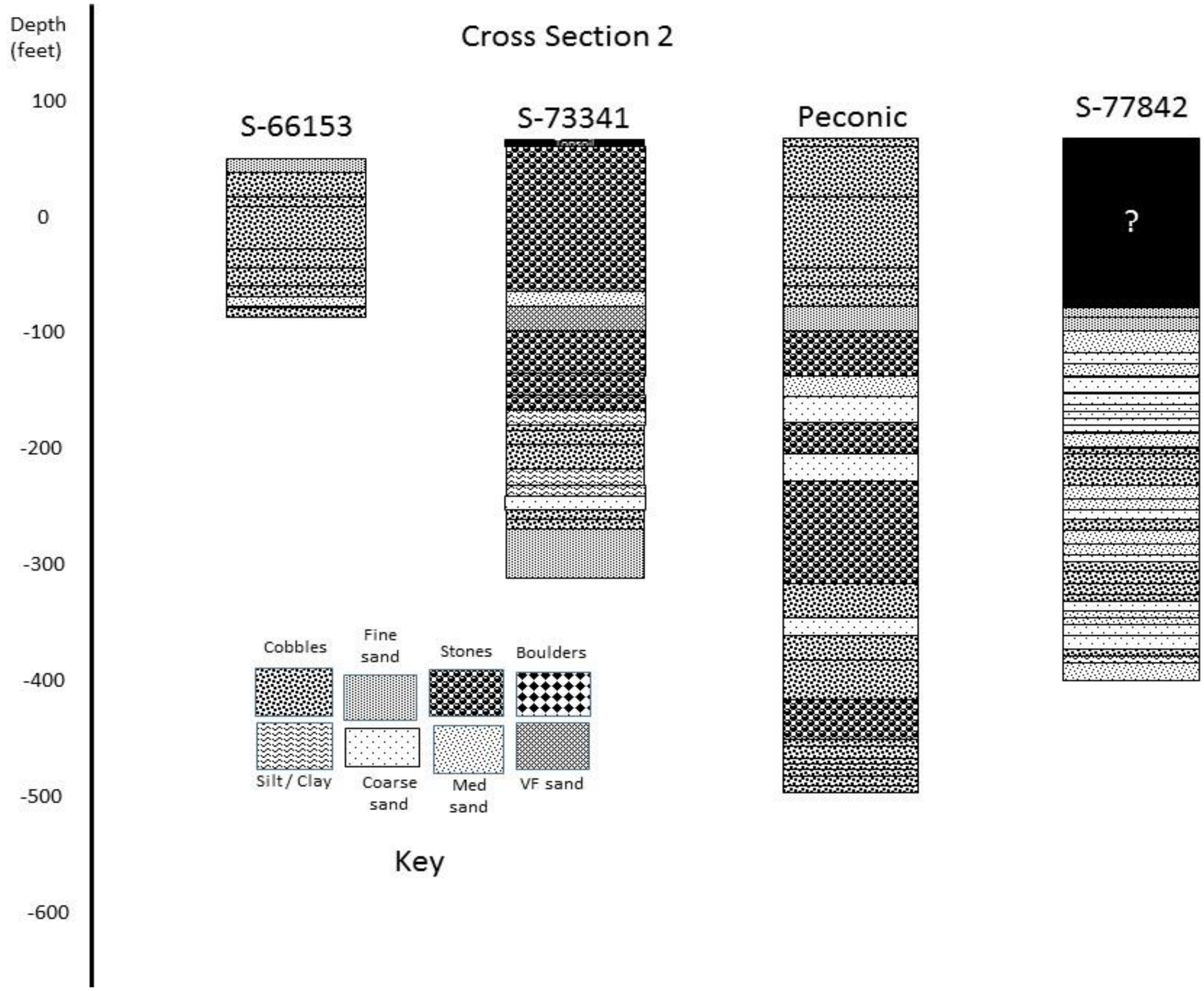

Figure 11- Strata of wells in cross section 2

Cross section 3: This section disagrees with Smolensky et al (1989) data by over 100 feet for each well. There are some limitations in the wells. Well S-37276 does not provide color for many of its sediments. It may be that the boundary is higher, but it is difficult to say with certainty. The plotted boundary for well S-30118 is not truly representative either, due to the fact that the well was all Pleistocene. A separate log that did not provide sediment color or grain size stated that the boundary was at a depth of 264 below sea level, but there was not enough data to be confident in this value. The surface topography does not match well with either interpreted boundary when juxtaposed with Figure 13. The wells in figure 14 do not have similar sections. Colors are missing from a few of the lower units in S-37276 that may be connected to S-38491, but they do not correlate well aside from this.

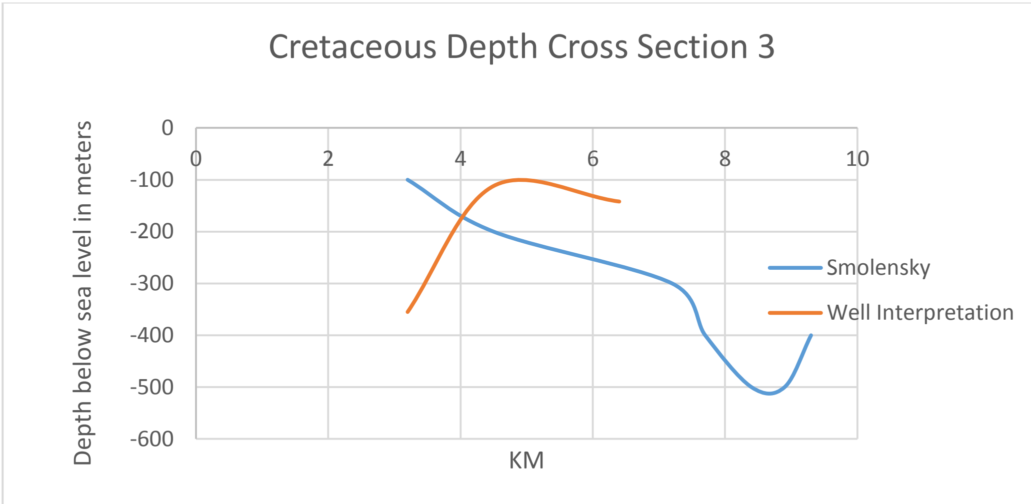

Figure 12- Cretaceous boundary from 3 to 3'

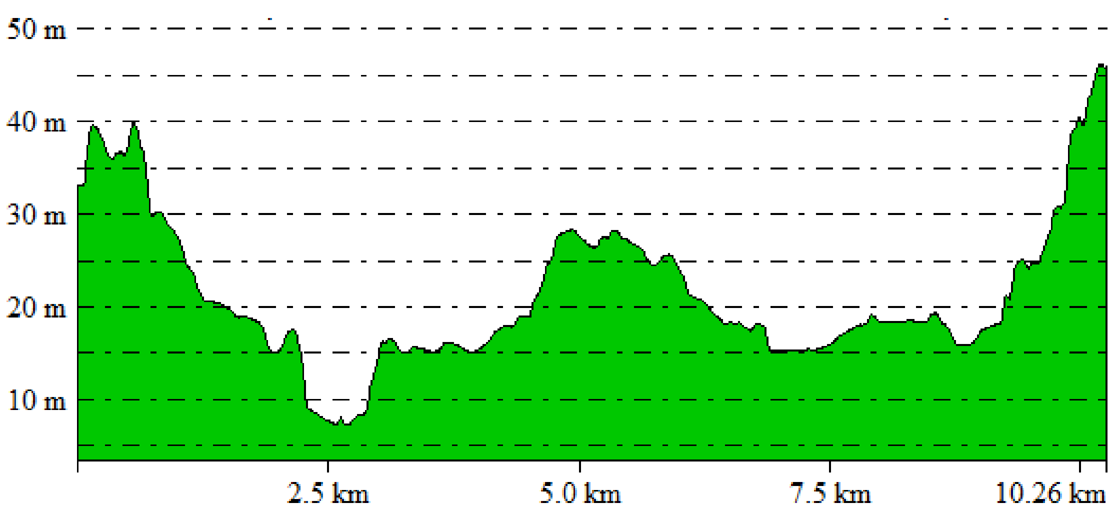

Figure 13- Surface elevation of 3 to 3' created using Global Mapper

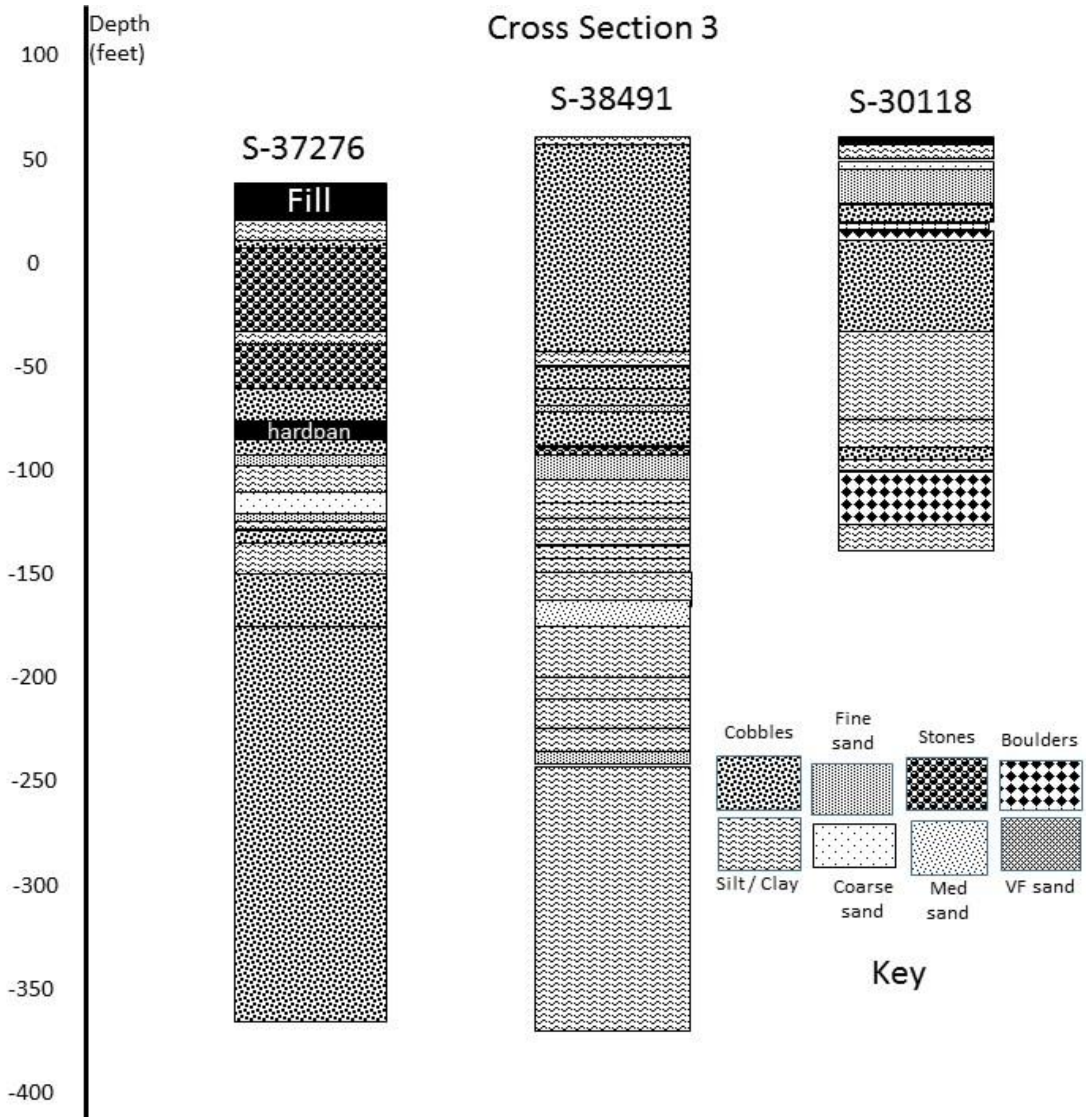

Figure 14- Strata of wells in cross section 3

Cross section 4: Figure 14 shows the interpretation of the upper Cretaceous boundary. S-39518 had very different results than the previously recorded boundary in cross section 4. This well is documented in detail in its log and is likely a better estimate than Smolensky et al (1989) provides. The surface topography is not very similar to either in that it is very jagged, as seen in figure 15. Like the wells in cross section 3, this cross section does not contain any correlations. Colors and grain size are very different and there is a lot of missing data from well SM-935 regarding its surface and upper sediments.

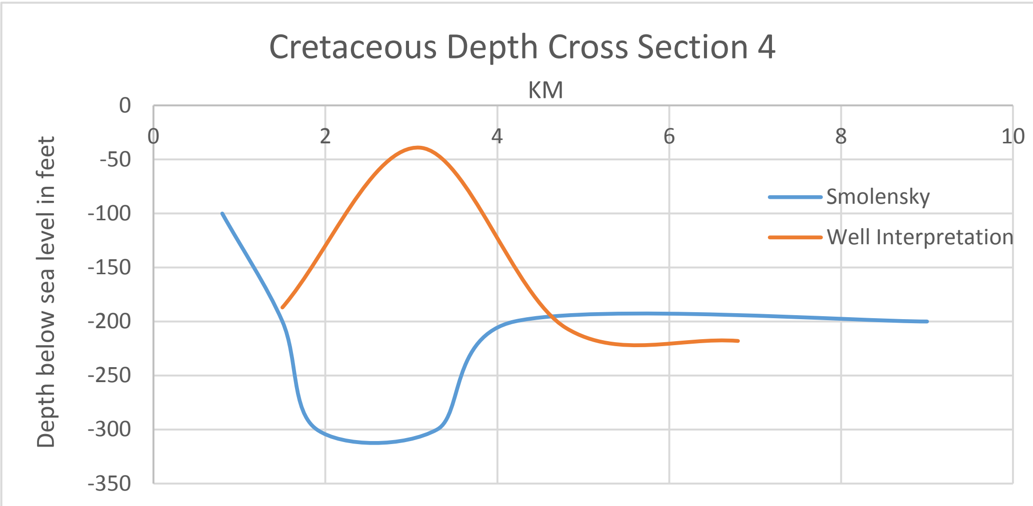

Figure 15- Cretaceous boundary from 4 to 4’

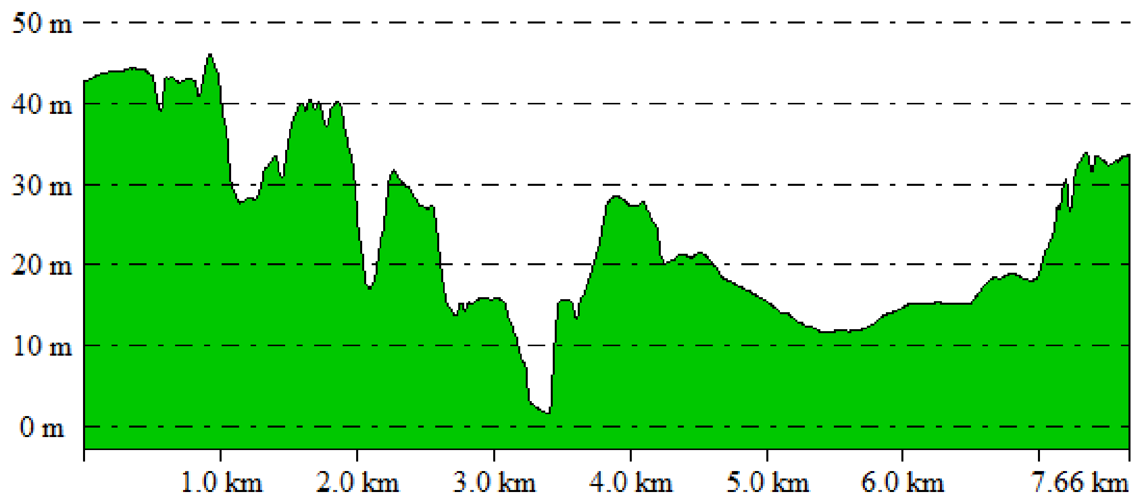

Figure 16- Surface elevation of 4 to 4’ created using Global Mapper

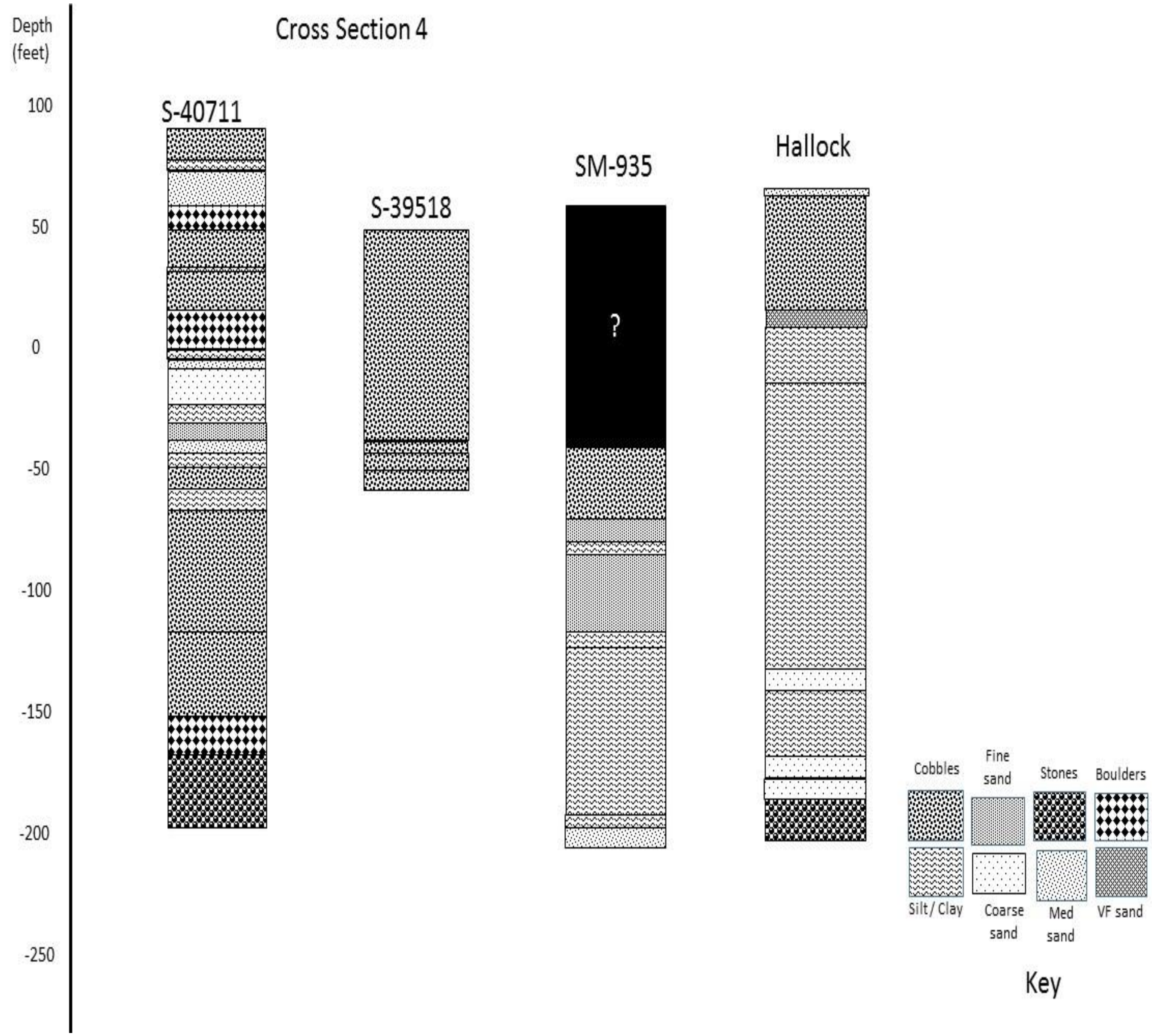

Figure 17- Strata of wells in cross section 4

North South Profiles

Based on the Pleistocene-Cretaceous boundary gathered from the well data, an overall profile could be constructed and contrasted to that provided by Smolensky et al. (1989). The profiles run from North (left) to south (right) as seen in figures 19 and 20 and are located along the corresponding letters (F and G) seen in figure 18. Two profiles were used for the data gathered in this study and is shown in figure 21 and in figure 22 and are listed as H and I. They do not show the Raritan Confining Unit or other deep formations due to the scope of this study.

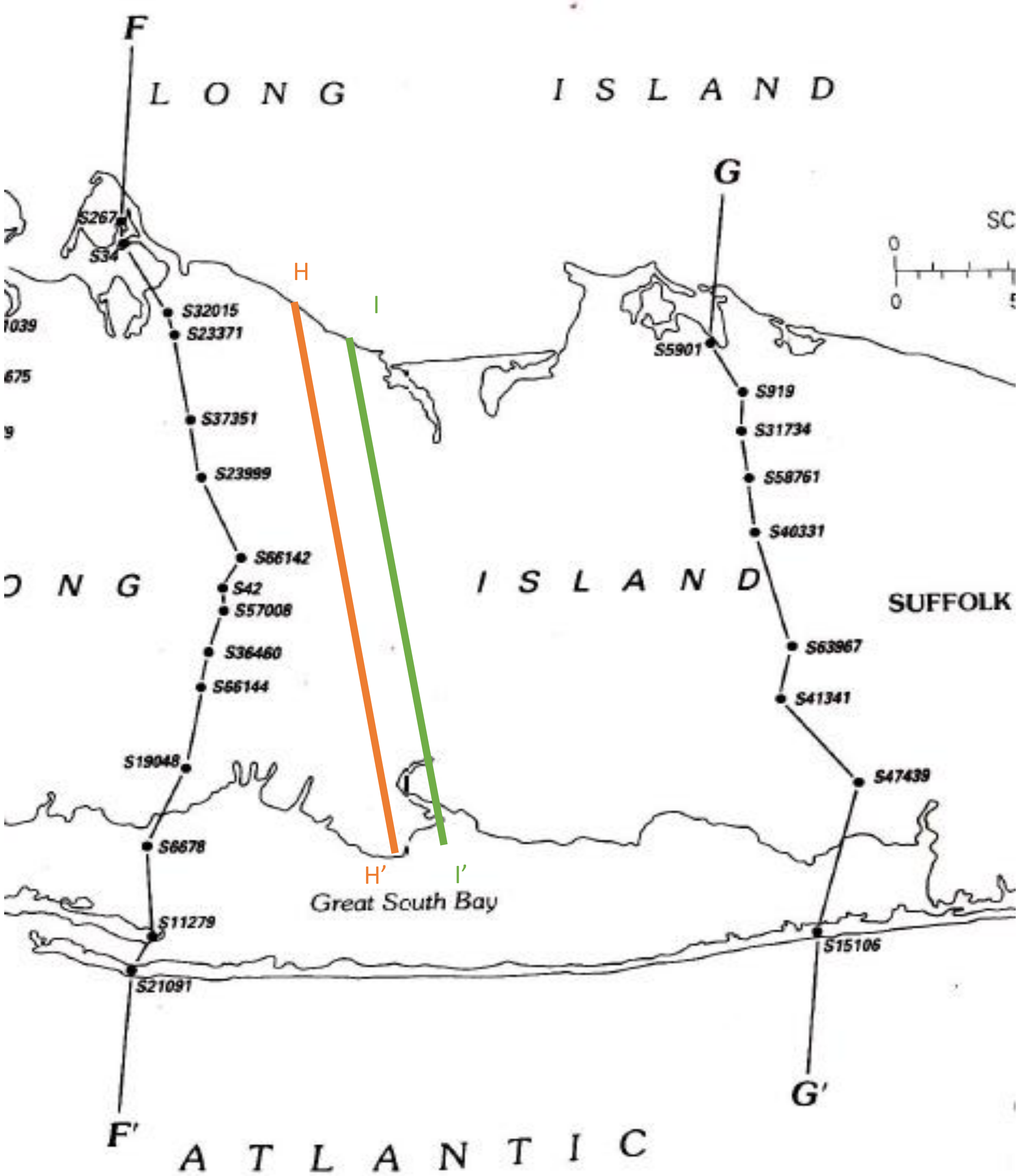

Figure 18 – Map from Smolensky et al (1989) showing cross sections of wells from North to South. The Orange line (H to H') and Green line (I to I') indicate two different profiles created from the wells used in this paper.

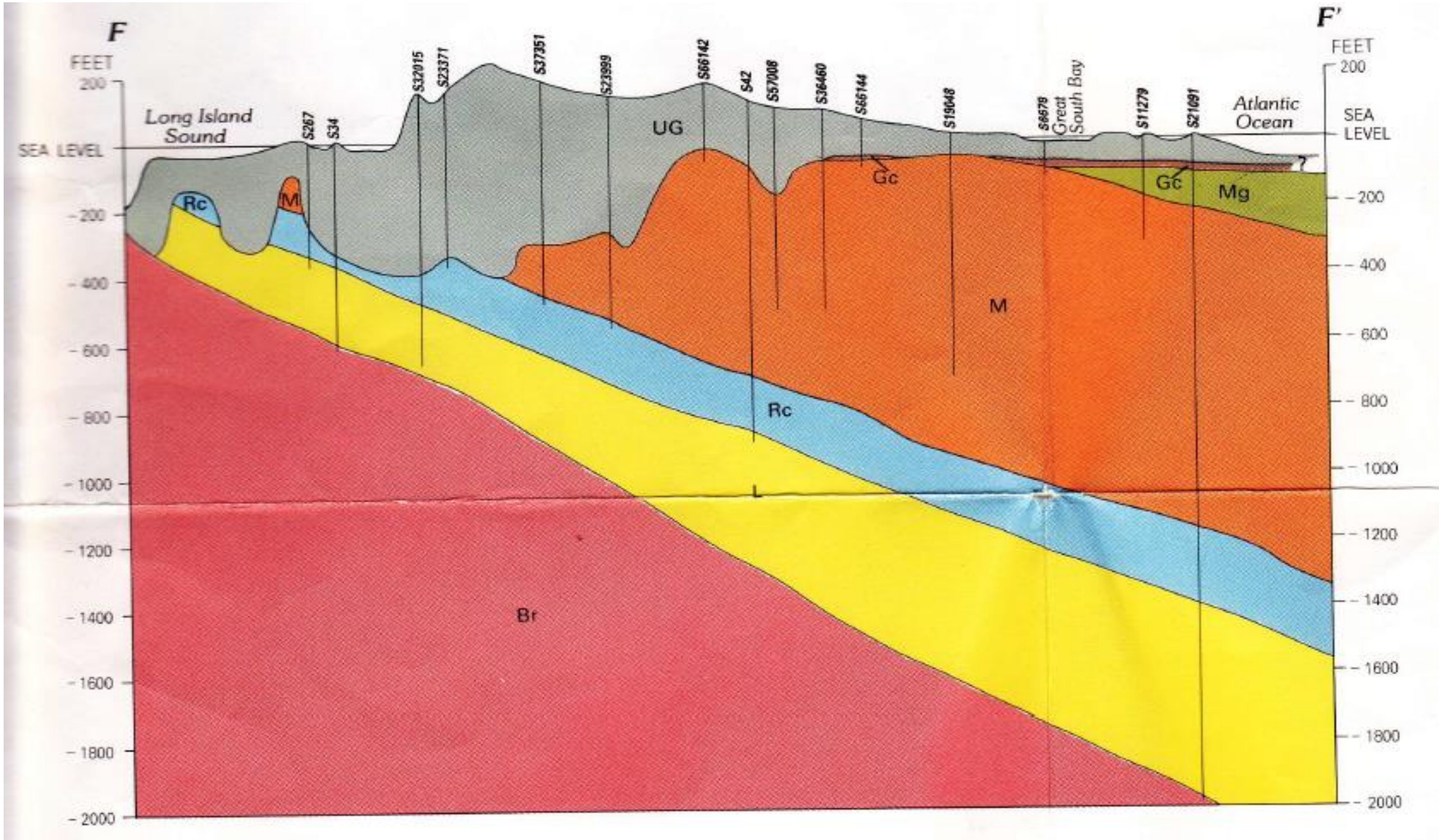

Figure 19 – F to F' formations based on well data from Smolensky

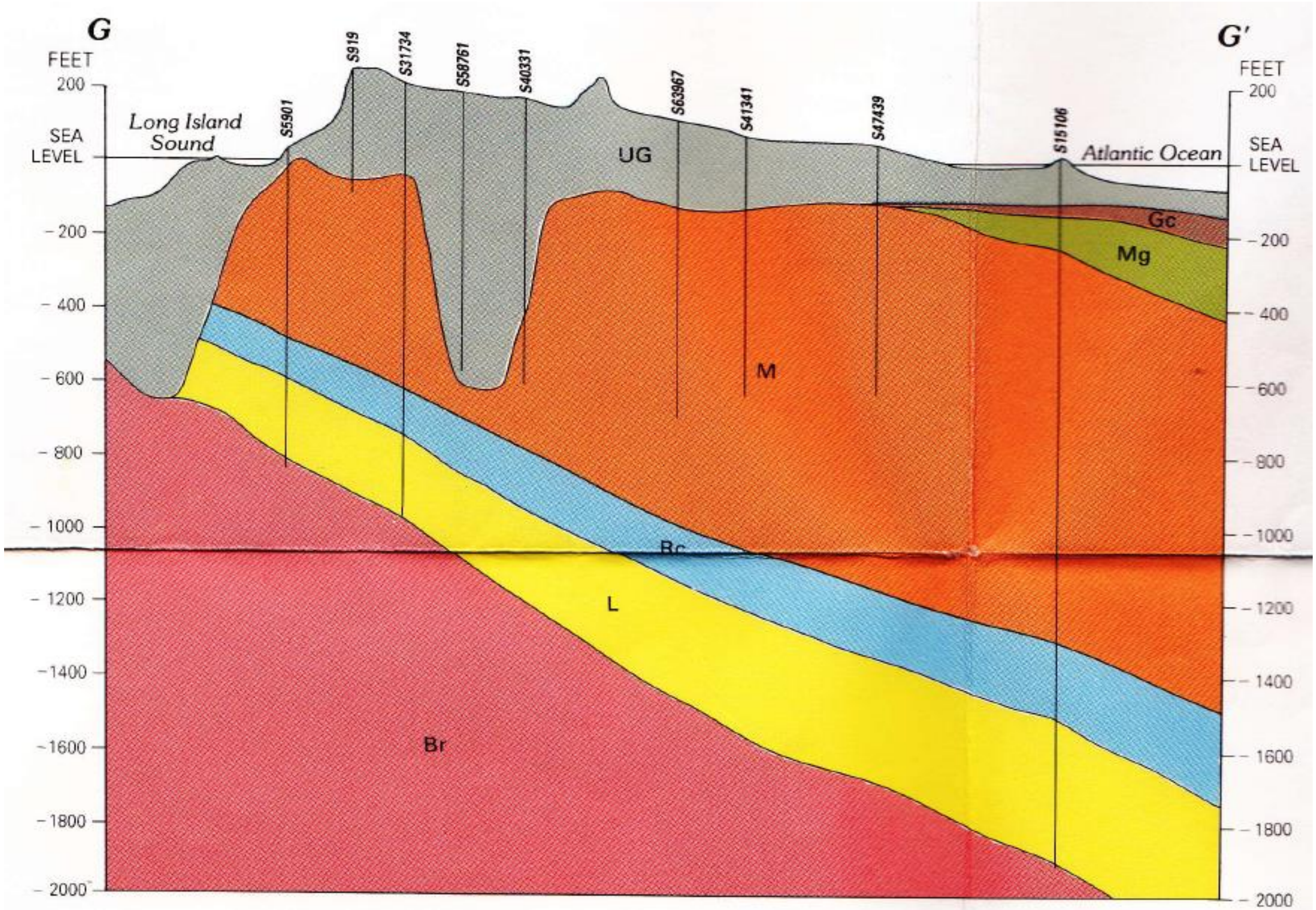

Figure 20 - G to G’ formations based on well data from Smolensky

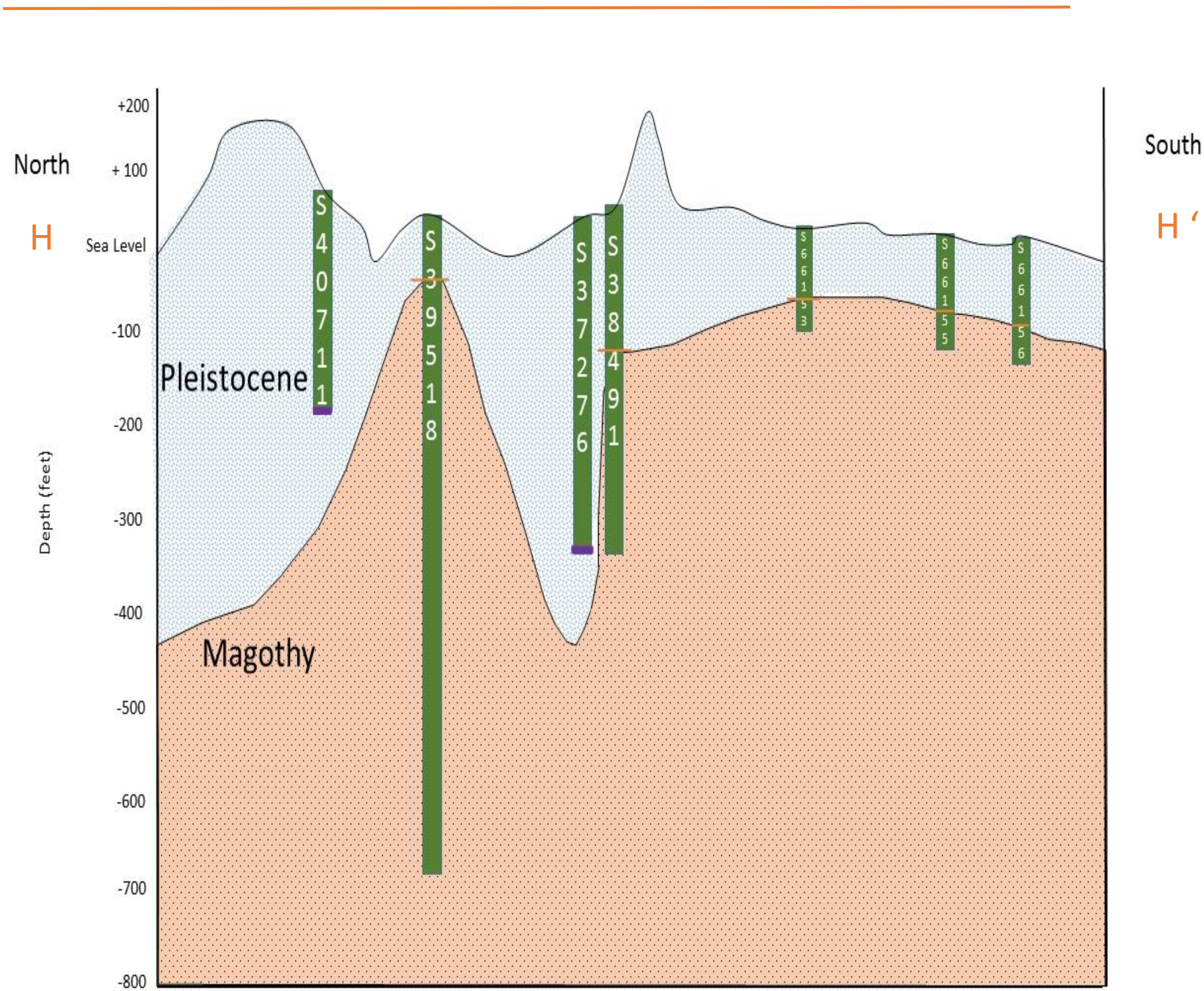

Figure 21 –North to south elevation profile and Pleistocene/Cretaceous boundary based on well data. Purple on bottom of well signifies that all sediment was glacial. An orange line along the well signifies a P/C boundary. Created with powerpoint.

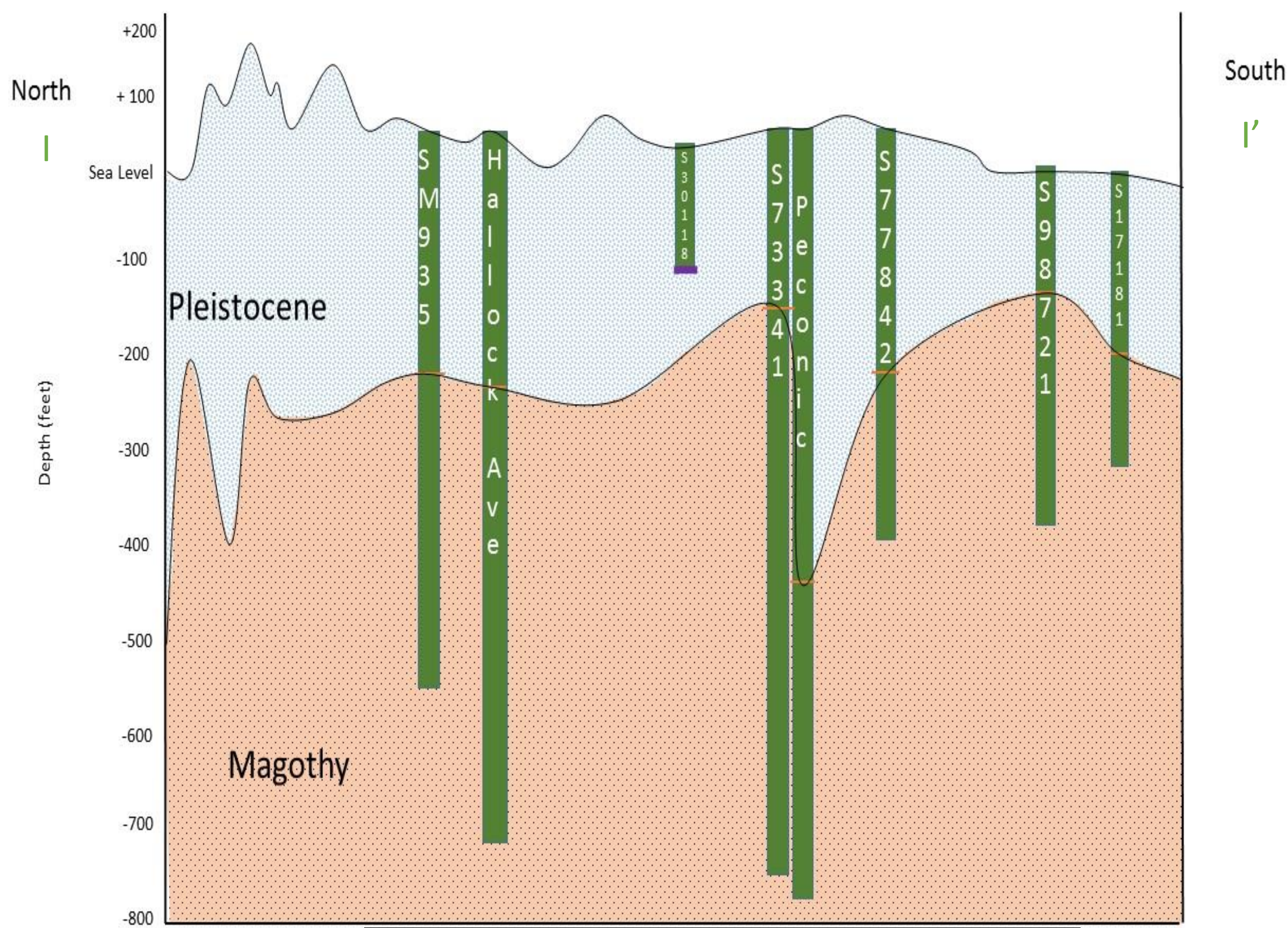

Figure 22- North to south elevation profile and Pleistocene/Cretaceous boundary based on well data. Marks are similar to that of figure 20.

Discussion

The surface topography may give some insight into the underlying features, but not enough to identify any feature outright. The well data does not support the existence of a tunnel valley in the Nissequogue River area or leading into the channel south of the Ronkonkoma Moraine. There are only some wells that show the signs of a tunnel valley based on infill patterns. Tunnel valleys are the result of very high energy events, therefore underlying sediment should be very coarse. Tunnel valleys are typically filled with very coarse sediments at their base (gravel, stones, boulders) that are then overlain by till and then by very fine sands or clay due to a proglacial lake or glacial meltwater depositional environment.

In cross section 1 there is no support for a tunnel valley. The only well in section 1 that appears to have an unsorted till layer is S-66156. This is odd because of how far south the well is of the Ronkonkoma Moraine. Though this is potentially till, there is no very coarse sediment at the bottom of the Pleistocene deposits and no sufficient tunnel valley shape from the cretaceous boundary data. Cross section 2 is similar to 1 in that there is only one well that contains what could be potentially till. S-73341 is underlain by coarse material at its base indicative of high energy but does not reside within an area that has a tunnel valley shaped cretaceous boundary. In section 3 there are two wells that contain till and are upwards fining, which are wells S-37276 and S-30118. Both wells have a limitation in that they do not have a Pleistocene Cretaceous boundary, so it is impossible to describe their oldest glacial unit. This also means that it is difficult to have a great projection of the shape of the subsurface boundary. Based on Smolensky et al (1989) data, it would appear that the shape is not indicative of a tunnel valley. In cross section 4, all but SM 935 contain till but show no tunnel valley structure based on their Cretaceous boundary data and do not have high energy basal units of Pleistocene origin. The Hallock well does appear to have the correct infill patterns to classify it as part of a tunnel valley, but it resides within a circular depression, not an elongated valley based on the cretaceous boundary data.

Within the circular depression, there are two thick clay layers. The Gardiners clay formation is usually greenish or blue and is commonly found with a maximum elevation around sea level on the north shore of Long Island (Weiss, 1954). The thickest clay layer is listed in the Hallock well as grey and found at 10 feet below sea level. Other indicators of this formation are shells from marine organisms, but no comment was made as to the content of shells in the Hallock well. Gardiners Clay has been discussed more recently as the North Shore Confining Unit or NSCU in the northern locations of Long Island (Stumm 2001). The NSCU matches the clay in the Hallock well and can be labeled NSCU rather than Gardiners clay. The NSCU in this feature belongs to the younger aged clay which formed from deposits that settled out in a proglacial lake setting as the glacier retreated and can be found primarily along the North Shore in Suffolk, Queens, and Nassau counties (Stumm, 2001). In Great Neck, NY the NSCU was found to be present and most abundant in deep valleys that are as deep as 200 feet below sea level and reach bedrock (Stumm, 2001). These valleys were filled with silt and clay but little gravel or sand, which is something they share in common with the Hallock well. The Manhasset, NY report had similar results to that of Great Neck, containing valleys that were filled with the NSCU and were similar depths. Outside of the valleys the NSCU ranged from 0 to 50 feet in thickness suggesting depressions are necessary for this unit to be prevalent (Stumm & Lange, 2002).

The large surface depression that can be seen south of the Nissequogue River is difficult to identify due to the large amount of development in the area and lack of well data. The data within the surface feature is mostly at its edges. Its surface does not correlate with a bowl shaped Cretaceous boundary based on Smolensky et al (1989) data or the new data. More well data may help to identify the general infill and provide a more precise cretaceous boundary in order to better classify the area.

The wells used do not have proper correlations due to the nature of glacial deposits and limitations in data. Till is difficult to correlate due to its time-transgressive nature; it is usually not deposited at the same time across a landscape (Benn, 2004). Till is identified by architectural elements such as lenses, interbedding, and stone clusters which the wells are not detailed enough to resolve (Benn, 2004). Braided streams describe most outwash streams and are difficult to identify due to their depositional nature as well. Braided streams are intertwining streams that resemble a complex braid and have highly differentiated discharge (Martini, 2001). Braided streams can be identified and classified, but sedimentary features such as cross bedding, laminations, and other cut and fill structures are required to really understand the path and infill of the stream (Martini, 2001). Unfortunately, the logs do not have precise data of sedimentary features or of any fining within a particular fill. Lack of sedimentary structure documentation and descriptions of the contacts between facies make correlating these wells correctly out of the scope of this study. Another factor that contributed to this was the distance between wells, which may have been too great to see less pronounced deposits.

The north south profiles of the Pleistocene and Cretaceous sediment based on the wells in this study are similar to the cross sections supplied by Smolensky et al (1989). The I to I' section (figure 22) and the H to H' (figure 21) are more similar to G than to F. This was unexpected to the closer proximity to F than to G for both sections. Section H follows the overall shape of G with a large depression in the northern region of Long Island. I is similar in that it has relatively similar shape, but the glacial material is deeper on average than G and the large depression is farther south. There are no closer North-South profiles to compare to.

There was no evidence in this study to promote an advance farther than the Ronkonkoma Moraine. Though there was some gravel found far south of the moraine, but was most likely the product of a meltwater stream. None of the other wells in cross section 1 contain coarse material and each well matches more with the hypothesis that the tunnel valley outlined in figure 23 existed. Cross sections 1 and 2 show signs of an outwash fan in the area given the decrease in energy from north to south. The sediment does not match an ice-proximal setting; it is much less coarse than its northern counterparts and there are no apparent glacial subsurface features, such as a tunnel valley or kettle hole, that would imply a further advance.

Though the data collected does not reveal any tunnel valleys within the Nissequogue River or Connetquot area, the search may have found a tunnel valley lying just to the east of well S-30118 that runs northward, west of the Ronkonkoma Kettle Lake and enters the Long Island Sound. Referring to figure 23, there is a deep, elongated valley that shows a Cretaceous boundary of ~500 feet below sea level. The wells south of the feature provide evidence for outwash generated by this feature. The wells show that the deposition in the area was mostly from fluvial sources (cross section 2 and cross section 1) and less energy was involved in the deposition of the sediments farther south than the proposed location of the tunnel valley. Because the tunnel valley lies outside of the wells, no infill data can be provided. Future study of the feature's infill would be necessary to identify that it is in fact a tunnel valley. Based on the reports from Manhasset and Great Neck, the depression should be filled with the NSCU and contain little sand or gravel (Strumm, 2001).

A feature that is not seen at the surface is a large circular depression surrounding the Hallock well in cross section 4, which encompasses most of Smithtown. This depression does not coincide with the large circular depression that is linked to the Nissequogue, but is east of it and smaller in size (figure 23). The proposed tunnel valley (in the same figure) wraps around it slightly from the east. It appeared to be caused by ice forming a large kettle hole that was filled in, but due to the fact that the depression is within the cretaceous sediment and the walls are cretaceous, it predates glacial activity. This feature is therefore older than ~23,000 years. Due to the erosion of the upper cretaceous, it is difficult to say what the extent of the depression was originally. Its round shape and relatively large size, about 5km diameter, could potentially be due to a meteor impact. If this is due to a meteor, then the size of the meteor would be about 220 meters in diameter based on a rough calculation using an online calculator (Beyer and Melosh, 1999). Using this size prediction, the frequency of such an impact event can be estimated with the graph shown in figure 24. The average time span between events of this magnitude is around about every 10,000 years (O'Connell, 2015). This is an infrequent event, but it could be a viable explanation. Further study of the lithology in this area would be required to better understand the feature. The presence of microspherules or other material that is suggestive of sudden high temperature events would be present at or under the Pleistocene Cretaceous boundary. The effects of the impact should also be found scattered around the impact site, so high temperature requiring materials would also be found outside the crater itself (O'Connell, 2015).

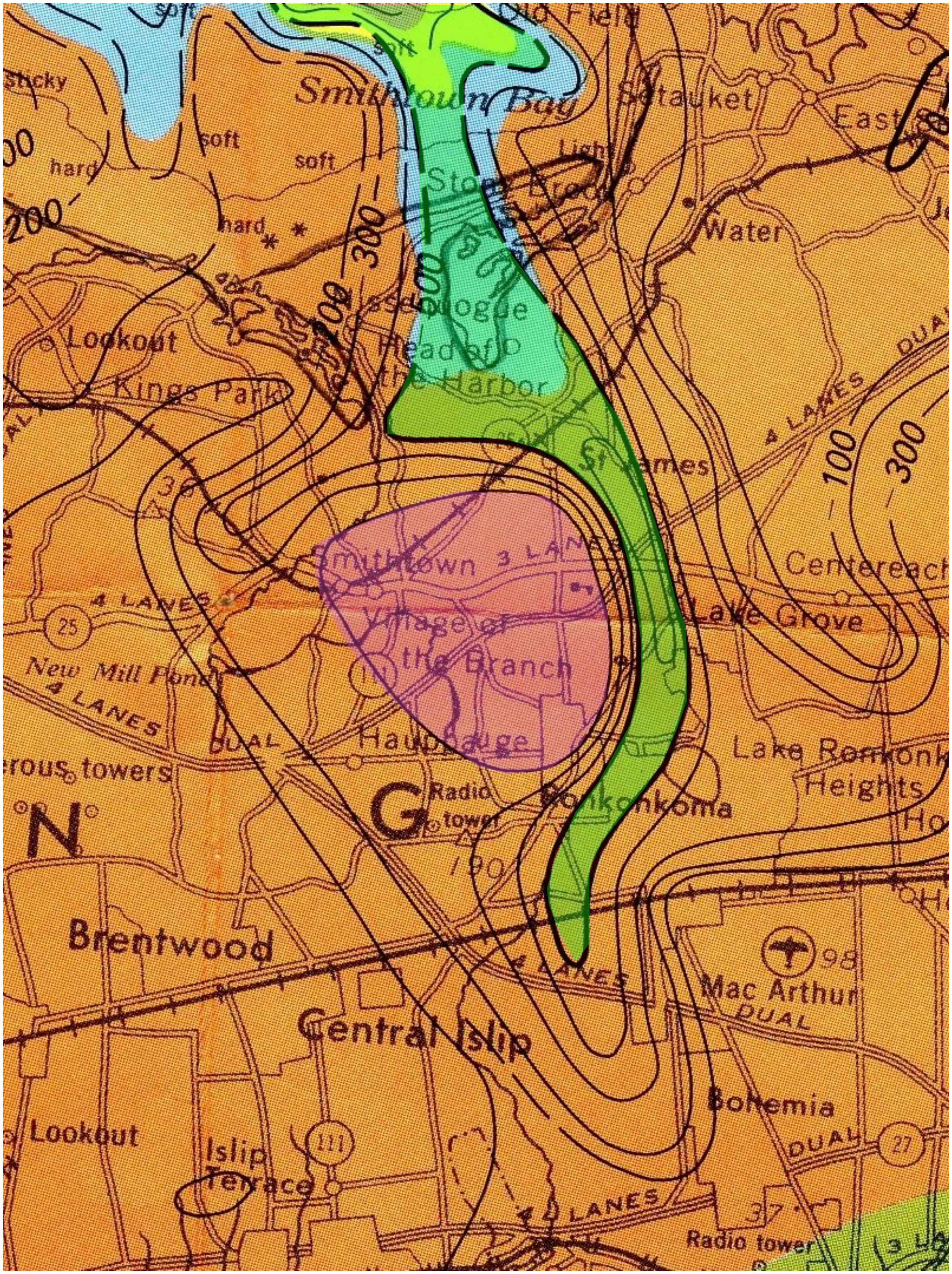

Figure 23- Tunnel valley (green) and large circular depression (purple) (Smolensky, 1989)

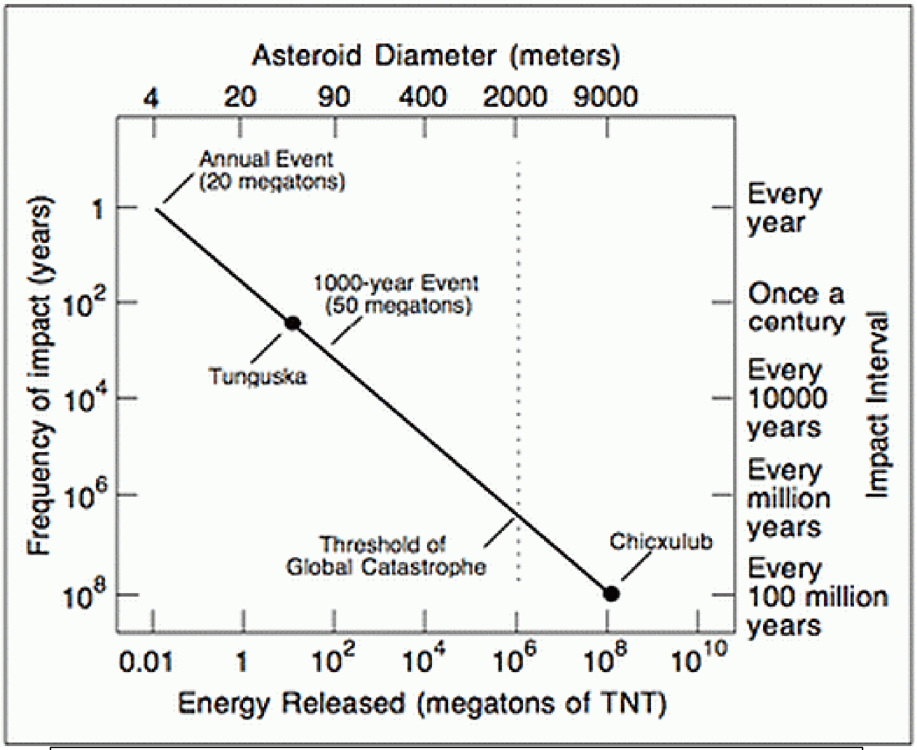

Figure 24- Graph of meteor size and frequency (note that the projectile would be about 220 m in diameter

References Cited

Benn, D. (2004). Facies description and the logging of sedimentary exposures. In A Practical Guide To The Study Of Glacial Sediments (pp. 35-41). New York, NY: Taylor & Francis.

Beyer, R., & Melosh, H. (1999, December 6). Computing Projectile Size from Crater Diameter. Retrieved May 10, 2015, from http://www.lpl.arizona.edu/tekton/crater_p.html

Doriski, T. (1983). GEOLOGY OF THE "20-FOOT" CLAY AND GARDINERS CLAY IN SOUTHERN NASSAU AND SOUTHWESTERN SUFFOLK COUNTIES, LONG ISLAND, NEW YORK. 6-7.

Hanson, G. (2015) Long Island DEM

Janszen, A., Moreau, J., Moscariello, A., Ehlers, J., & Kröger, J. (2012). Time-transgressive tunnel-valley infill revealed by a three-dimensional sedimentary model, Hamburg, north-west Germany. Sedimentology, (60), 693-719

Kehew, A., Piotrowski, J., & Jørgensen, F. (2012). Tunnel valleys: Concepts and controversies - A review. Earth-Science Reviews, 113, 33-58.

King, C., Mion, L., Pacholik, W., & Hanson, G. (n.d.). EVIDENCE OF TILL SOUTH OF RONKONKOMA MORAINE

Krohn, C., Larsen, N., Kronborg, C., Nielsen, O., & Knudsen, K. (2009). Litho- and chronostratigraphy of the Late Weichselian in Vendsyssel, northern Denmark, with special emphasis on tunnel-valley infill in relation to a receding ice margin. Boreas, 811-833.

Lewis, R. (1995). GEOLOGIC HISTORY OF LONG ISLAND SOUND. Tidal Marshes of Long Island Sound, (34), 13-16.

Martini, I., & Brookfield, M. (2001). Meltwater Stream Characteristics and Deposits. In Principles of glacial geomorphology and geology. Upper Saddle River, N.J.: Prentice Hall.

O'Connell. (2015, May 1). 22: IMPACTS AND BIO-EXTINCTIONS. Retrieved May 10, 2015, from http://www.astro.virginia.edu/class/oconnell/astr1210/guide22.html

Piotrowski, J. (1994). Tunnel-valley formation in northwest Germany—geology, mechanisms of formation and subglacial bed conditions for the Bornhöved tunnel valley. Sedimentary Geology, 107-141.

Sirkin, L.A., 1986, Palynology and Stratigraphy of Cretaceous and Pleistocene Sediments on Long Island, New York – A Basis for Correlation with New Jersey Coastal Plain Sediments. United States Geological Survey Bulletin 1559.

Smolensky, D.A., Buxton, H.T., and Shernoff, P.K., 1989, Hydrologic framework of Long Island, New York : U.S. Geological Survey Hydrologic Investigations Atlas HA- 709, 3 sheets, scale 1:250,000.

Stumm, F. (2001). Hydrogeology and extent of saltwater intrusion of the Great Neck peninsula, Great Neck, Long Island, New York. Coram, N.Y.: U.S. Dept. of the Interior, U.S. Geological Survey ;.

Stumm, F., & Lange, A. (2002). Hydrogeology and extent of saltwater intrusion on Manhasset Neck, Nassau County, New York. Coram, N.Y.: U.S. Dept. of the Interior, U.S. Geological Survey

Weiss, L. (1954). Foraminifera and origin of the Gardiners Clay (Pleistocene), Eastern Long Island, New York. Washington: U.S. Govt. Print. Off.

Well Logs Cross Section 1 (wells S-66155, S-66156, S-17181, S-98721)

S- 66155
Surface Elevation: 30 feet above sea level

Depth (feet)	Description
0-15	Sand and gravel, coarse brown- Iron oxide staining
15-45	Same
45-55	Sand, medium-coarse , brown ; gravel brown; muscovite mica
55-65	Sand, fine-coarse, brown; mica, iron oxide
65-70	Sand, fine-coarse, brown, same small iron oxide pieces and mica
70-95	Same
95-100	Sand, medium-coarse, brown; some gravel
100-105	Standard gravel, medium to coarse brown, iron oxide staining
105- 110	Clay, bluish gray (shell fragments)
110-115	Same
115-120	Same
120-125	Clayey sand, grey, sand is fine to medium
125- 135	Sand, fine-medium, grey, muscovite, some lignite and pyrite
135-145	Same
145-155	Sand, fine to medium, grey, lignite

Geologic Correlation
0-101 = recent and Pleistocene
101-118 = Gardiners Clay
118-155= Matawan Group- Magothy Formation undifferentiated

S-66156
Surface Elevation: 18 feet above sea level

Depth (feet)	**Description**
0-20	Sand, fine to coarse, brown
20-45	Sand, fine to medium, tan-brown
46-62	Sand and gravel, fine to coarse, tan-brown, iron oxide
62-82	?
82-90	Sand, fine to medium, brown
90-95	Sand, fine, tan-brown
95-100	Same
100-107	Sand and gravel, fine to coarse, tan
107 – 112	Sand and gravel, fine to coarse, tan-brown. Small grey clay pieces in wash
112-115	Clay, brown and grey, sand and gravel, fine to medium, tan
115-120	Pieces of grey, brown, and greenish clay along with sand and gravel, fine to medium
121 to 130	Clay, dark grey and greenish grey; sand, fine, grey
130 - 140	Clay, greyish black; sand, medium, dark grey
140 – 150	Sand, fine to medium, greyish white; lignite
150 – 163	Sand, fine to medium, greyish white; lignite
163 – 173	Sand, fine to medium, greyish white; lignite

Geologic Correlation
0-110= Recent and Pleistocene
110-130= Gardiners Clay
130-173= Matawan group- Magothy Formation undifferentiated

S 17181
Surface Elevation – about 3 feet above sea level

Depth (feet)	Description
0-4	Bog
4-40	Medium sand- grits
40-102	Fine Sand
102-105	Sand and Gravel
105- 109	Gray sand and gravel
109 – 125	Solid gray clay
125 – 128	Silt
128 – 130	Gray clay
130 – 155	Gray sand in soupy clay
155 – 185	Fine gray sand
185 – 186	Bog
186 – 191	Soupy clay
191 - 197	Silt
197 – 203	Black clay
203 – 228	Gray sand in soupy clay
228 – 231	Gray clay
231 – 237	Medium fine sand
237 – 249	Solid gray clay
249 – 280	Gray sand in soupy clay
280 – 293	Soupy clay
293 – 296	Gray clay
296 – 314	Medium fine sand

S – 98721
Surface Elevation – 13 feet above sea level

Depth (feet)	**Description**
0 – 2	Topsoil
2 – 18	Brown sand coarse gravel
18 - 19	Big Stones
19 – 50	Brown sand coarse gravel
50 – 80	Fine to coarse, light brown sand
80 – 122	Fine brown sand
122 – 128	Coarse brown sand – Small stones
128 – 130	Greenish brown clay
130 – 140	Sandy green marl
140 – 156	Dense black clay (slow drilling)
156 – 220	Coarse – medium – fine sand
220 – 230	Clay and sand laminated
230 – 250	Fine gray sand
250 – 257	Sticky black clay (slow drilling)
257 – 270	Silty gray clay
270 – 300	Fine to medium gray sand with lignite
300 – 302	Silty gray clay
302 – 313	Fine to coarse sand
313 – 320	Sand and clay laminated
320 – 398	Fine to medium gray sand ; streaks of charcoal

Well Logs Cross Section 2 (Wells S-66153, S-73341, Unnamed well on Peconic Street, S-77842)

S – 66153

Surface Elevation – 50 feet above sea level

Depth (feet)	Description
0 – 5	Sand, Fine, brown, topsoil
5 – 30	Sand, medium to coarse, brown, subangular to subrounded, quartz, feldspar, rock fragments. Gravel- small to 4'' diameter
30 – 50	Sand, fine to coarse, light brown, sub-angular, quartz; some gravel, less than 1'' diameter
50 – 63	Same
63 – 75	Same but some orange stained gravel
75 – 95	Sand, fine to coarse, light brown to orange stained, angular to sub-rounded, mostly quartz, some rock fragments, very little gravel
95 – 103	Sand, medium to coarse, light brown to clear, sub-angular to sub-rounded, mostly quartz, some rock fragments, several layers of fine to medium gravel
103 – 113	Same
113 – 118	Sand, fine to medium, reddish yellowish brown, angular to subrounded, quartz, some mica. Large gravel up to 6'' in diameter
118 – 123	Sand, medium to coarse, light gray, angular to subangular, quartz, mica, several pieces of white clay and iron oxide
123 – 133	Sand, medium to very coarse, clear to white, angular-subangular quartz, some white clay
133 – 143	Sand, fine to medium, light gray, quartz, more mica, subangular, some white clay
143 – 153	Sand, very fine to medium, light gray, mica, quartz, Clay, white, several layers
153 – 163	Same

Geologic Correlation

0 -118=Recent and Pleistocene

118- 163= Matawan group – Magothy Formation undifferentiated

S – 73341

Surface Elevation- 64 feet above sea level

Depth (feet)	Description
0 – 2	Top soil
2 – 118	Medium to coarse brown sand with gravel and cobbles
118 – 125	Fine to medium brown sand with mica
125 – 172	Very fine brown sand with mica
172 – 205	Fine brown sand with gravel and fine cobbles
205 – 215	Fine to coarse brown sand with fine to coarse gravel and cobbles
215 – 224	Same
224 – 233	Solid multicolored clay
233 – 240	Fine to coarse brown sand with mica, hardpan, fine to medium gravel and clay
240 – 255	Fine to medium brown sand with mica and some coarse gravel
255 – 270	Fine gray sand with gravel and streaks of clay
270 – 290	Fine to gray sand with streaks of clay
290 – 295	Fine brown sand with mica and bits of clay
295 – 312	Medium to coarse tan sand with grits, mica and hardpan
312 – 314	Solid dark gray clay with embedded gravel
314 - 325	Medium to coarse tan sand with mica and gravel
325 – 377	Fine gray sand
377 – 412	Gray sandy clay with mica, lignite, and pyrite
412 – 421	Solid light and dark gray clay
421 – 431	Fine to medium gray sand with some lignite and sandy clay
431 – 440	Layers of multilayered sand and sandy clay with lignite and streaks of clay
440 – 445	Multicolored sandy and solid clay
445 – 490	Fine gray sand with streaks of clay
490 – 493	Solid and sandy grey clay with lignite
493 – 505	Fine gray clayey sand with lignite
505 – 545	Fine gray clayey sand with pyrite, lignite, and mica
545 – 620	Fine to medium gray sand with mica and lignite
620 – 665	Fine to coarse grey sand with mica, lignite, traces of clay and fine gravel
665 – 686	Very fine gray sand with streaks of clay and gravel
686 – 690	Coarse light brown sand with gravel
690 – 702	Coarse gray sand and fine gravel with lignite and some layers gray clay
702 – 718	Fine to coarse gray sand with fine gravel, mica, lignite, and streaks of gray clay
718- 745	Fine to medium gray sand with mica, lignite, fine gravel, and some clay
745 – 794	Coarse gray sand with gravel
794 – 798	Solid multicolored clay
798 - ?	Medium to coarse gray sand with gravel

Peconic Street well
Surface Elevation: 66 feet above sea level

Depth (feet)	Description
0 – 6	Coarse brown sand and heavy gravel
6 – 60	Medium to coarse brown sand and heavy gravel
60 – 105	Medium to coarse brown sand and small gravel
105 – 118	Coarse multicolored sand and large gravel
118 – 130	Medium to coarse brown sand and grit
130 – 171	Fine brown sand and mica
171 – 210	Medium to coarse brown sand and large gravel with large stones
210 – 218	Medium brown sand
218 – 240	Medium to coarse brown sand
240 – 270	Coarse brown sand, gravel, and large stones
270 – 285	Coarse brown sand
285 – 398	Coarse brown sand and stones and gravel
398 – 410	Coarse brown sand and gravel
410 – 418	Medium to coarse brown sand
418 – 440	Coarse brown sand and gravel
440 – 485	Coarse brown sand and grit with some gravel
485 – 514	Coarse brown sand, heavy gravel, and large stones
514 – 516	Coarse red sand and gravel
516 – 527	Coarse brown sand and gravel
527 – 531	Coarse red sand and small gravel
531 – 534	Coarse brown sand and gravel with bits of tan clay
534 – 541	Coarse red sand and small gravel (discharge is blood red)
541 – 550	Coarse brown and multicolored sand with small gravel
550 – 569	Coarse brown sand and grit
569 – 590	Fine gray sand some solid gray clay with mica
590 – 645	Fine gray sand and mica
645 – 647	Lignite and pyrite within fine gray sand
647 – 658	Solid gray clay
658 – 685	Fine to medium gray sand
685 – 706	Fine to coarse gray sand
706 – 708	Lignite and pyrite in some fine gray sand
708 – 711	Solid dark gray clay
711 – 735	Fine to medium gray sand with bits of clay
735 – 740	Multicolor gray clay with medium to coarse gray sand
740 – 752	Gray clay with fine to medium gray sand
752 – 759	Gray clay with medium to coarse gray sand
759 – 788	Fine to medium gray sand with bits of clay
788 – 838	Medium to coarse gray sand with small gravel and some solid gray clay
838 – 850	Medium to coarse gray sand
850	White sandy clay

S- 77842
Surface Elevation: 57 feet above sea level

Depth (feet)	Description
0-152	?
152 – 162	Sand, very fine to fine, tan
162- 171	Sand, fine, grey
171- 181	Sand, coarse, grey
181 – 191	Sand, fine to medium, grey with ran clay stringers
191- 200	Sand, medium to coarse, grey
200 – 210	Sand, medium to coarse, grey
210 – 220	Sand, medium to coarse, tan
220 – 229	Sand, medium to coarse, tan
229 – 239	Sand, medium to coarse, tan
239 – 249	Sand, medium to coarse, tan
249 – 258	Sand, medium, white
258 – 268	Sand, medium to coarse, light tan, some fine gravel
268 – 278	Sand, medium to coarse, light tan, some fine gravel
278 – 287	Similar to above
287 – 297	Sand, very fine to medium, silty, greenish glauconite
297 – 306	Sand, fine to medium, silty, greenish-tan, glauconite
306 – 316	Sand, fine to coarse, greenish-tan with clay stringers greyish tan
316 – 326	Sand, fine to coarse, tan with fine gravel
326 – 335	Sand, medium, greyish-tan
335 – 345	Sand, medium, greyish-tan
345 – 355	Sand, medium to coarse, grey
355 – 364	Sand, medium to coarse, tan with some fine gravel
364 – 374	Sand, medium to coarse, tan with some fine gravel
374 – 383	Sand, fine to coarse, grey with some fine gravel
383 – 393	Sand, medium to coarse, grey with some fine to medium gravel
393 – 403	Sand, fine to coarse, tan
403 – 413	Sand, fine to medium, slightly silty, greenish-grey
413 – 422	Sand, fine to medium, greyish-tan
422 – 432	Sand, fine to coarse, greyish-tan
432 – 442	Sand, fine to coarse, greenish-grey
442 – 451	Same as above with fine gravel
455	Sandy clay, light green, glauconitic
455 - 461	Sand, fine to medium, greenish tan, slightly glauconitic
466	Magothy surface- distinct drilling pressure change
466 – 471	Sand, very fine to fine, clayey, brown to black, lignitic
471 – 480	Sand, fine to medium, tan, white, purple, and greenish streaks with some sandy silt, greenish-tan

Geologic correlation
0 - 462 = Pleistocene deposits
462 – 480 = Magothy deposits

Well Logs Cross Section 3 (S-37276, S-38491, S-30118)

S-37276

Surface Elevation: 46 feet above sea level

Depth (feet)	Description
0 – 10	Fill
10 – 33	Brown and grey clay
33 – 35	Gravel, streaks of brown sand and brown clay
35 – 76	Gravel, stones, rocks, streaks of brown clay and sand
76 – 81	Brown clay
81 – 112	Gravel, stones, brown sand
112 – 123	Brown clay, streaks of sand and gravel
123 – 126	Hard pan
126 – 138	Sand and gravel
138 – 146	Fine brown sand
146 – 173	Tan clay, very little sand
173 – 178	Coarse sand
178 – 180	Fine sand
180 – 183	Fine sand, sandy red clay
183 – 192	Fine sand, streaks of clay and mica
192 – 204	Streaks of clay with silty sand
204 – 225	Coarse sand, streaks of clay, mica, fine gravel
225 – 402	Fine and coarse sand with streaks of clay and heavy gravel

Geologic Correlations
349 to 399 = Smithtown clay

S- 38491
Surface Elevation: 67 feet above sea level

Depth (feet)	Description
0-2	Topsoil, brown clay
2 – 110	Coarse brown sand and gravel
110 – 112	Fine brown silty sand
112 – 125	Coarse brown sand and gravel
125 – 131	Brown, gray sandy clay with some gravel
131 – 134	Fine brown sand
134 – 155	Coarse brown sand with gravel
155 – 164	Fine brown sand with large stones
164 – 174	Fine light brown sand
174 – 179	Sandy multicolored clay
179 – 183	Fine light brown sand with clay
183 – 185	Solid multicolored clay
185 – 192	Hard gray clay
192 – 200	Multicolored clay
200 – 219	Fine multicolored sand with streaks of white clay
219 – 235	Fine sandy clay, mica, (drills hard)
235 – 250	Medium sand, multicolored clay (drills hard)
250 – 268	Fine brown sand with streaks of multicolored sand
268 – 270	Sandy multicolored clay
270 – 276	Dark gray clay, brown silty clay
276 – 280	Same as above
280 – 295	Fine brown sand
295 – 297	Light brown clay and silty clay
297 – 333	Fine brown sand, streaks of clay clayey sand
333 – 343	Fine gray and brown sand
343 – 347	Fine gray sand
347 – 375	Fine brown sand
375 – 385	Fine gray sand with strips of gray clay
385 – 393	Fine light ray sand
393 – 402	Medium light gray sand
402 – 403	Medium to coarse gray sand with white clay

Geologic Correlations
164 – Glacial
Between 270 – 276 = Matawan Magothy

S – 30118
Surface Elevation: 55 feet above sea level

Depth (feet)	Description
0 – 1	Top soil
1 – 3	Loam
3 – 5	Coarse brown sand
5 – 21	Fine brown sand
21 – 26	Medium brown sand and gravel
26 – 27	Brown clay and boulder
27 – 31	Coarse brown sand and boulders
31 – 81	Fine to medium to coarse brown sand and gravel
81 – 126	Fine brown sand, mica and bits of brown clay
126 – 147	Very fine silty brown sand, mica, bits of brown clay
147 – 150	Fine, medium to coarse brown sand and grits
150 – 152	Silty brown sand (streaks of brown clay)
152 – 189	Fine to medium to coarse brown sand, large gravel and boulders
189 – 197	Fine brown sand, streaks of brown clay

Geologic Correlation
All Pleistocene

Well Logs Cross Section 4 (Wells S-40711, S-308.1, S-39518, SM-935, unnamed well at Hallock Avenue)

S – 40711
Surface Elevation: 91 feet above sea level

Depth (feet)	Description
0 – 10	Fine brown sand and gravel
10 – 12	Fine gray sandy clay
12 – 24	Fine to medium brown sand
24 – 30	Coarse brown sand and gravel and boulders
30 – 41	Fine brown sand, grits and gravel
41 – 43	Brown clay
43 – 49	Fine, medium, and coarse brown sand and gravel
49 – 67	Coarse brown sand and boulders
67 – 71	Brown clay
71 – 75	Medium brown sand with brown clay streaks
75 – 99	Coarse brown sand
99 – 102	Brown clay and streaks of fine brown sand
102 – 112	Fine brown sand
112 – 127	Fine to medium brown sand with streaks of brown clay
127 – 132	Fine brown sand with streaks of brown clay
132 – 144	Medium to coarse brown sand, grits and gravel
144 – 151	Fine brown clayie sand
151 – 207	Medium to coarse brown sand and grits
207 – 239	Fine to coarse sand with clay streaks and gravel
239 – 248	Coarse brown sand with gravel and boulders
248 – 278	Fine to medium brown sand and large stones

S – 39518
Surface Elevation: 60 feet above sea level

Depth (feet)	Description
0 – 74	Small to large gravel, coarse brown sand
74 – 75	Sandy brown clay, some gravel
75 – 90	Small to medium gravel, some brown sand
90 – 99	Small to large gravel, some sand and streaks of brown sandy clay
99 – 103	White fine sand, some clay, some gravel
103 – 104	White sandy clay, some gravel with a white sand
104 – 109	White sand, small to large gravel, some white clay
109 – 140	Fine to medium white sand, some small gravel
140 – 151	White and gray clay, some gravel
151 – 171	Fine white sand, small amounts of gravel and hardpan
171 – 174	Multicolored clay, some hardpan and small amounts of lignite
174 – 176	Gray clay
176 – 180	Some gray clay, small to large gravel, coarse white sand
180 – 190	Small to large gravel with coarse white sand
190 – 205	Some multi colored clay, some gravel, coarse white sand
205 – 210	Gray clay and coarse white sand
210 – 220	Small to large gravel and white sand
220 – 228	Gray clay
228 – 242	Fine white sand, some white sandy clay
242 – 243	Fine to medium white sand, white and brown clay, some gravel
243 – 247	Fine white sand, some gravel, bits of clay
247 – 260	Fine white sand, some hardpan and grits
260 – 272	Gray clay, some hardpan
272 – 308	Fine white sand
308 – 310	Fine white sand, hardpan, gray clay
310 – 345	Fine white sand
345 – 352	Fine white sand, some small gravel, some gray clay
352 – 362	Gray clay, small gravel
362 – 364	Coarse white sand
364 – 366	Gray clay
366 – 370	Light and dark hard gray clay, some small to medium gravel
370 – 387	Gray clay with fine sand, some bits of black clay
387 – 400	Fine to medium white sand, mica
400 - 445	?
445 – 460	White sand and some white clay
460 – 475	Small gravel and some white clay
475 – 487	Coarse white sand, some white clay
487 – 496	White sandy clay, fine white sand
496 – 512	Fine to coarse white sand, some clay
512 – 518	White clay, some fine white sand
518 – 521	Gray clay, fine white sand
521 - 535	Solid gray clay, small to medium gravel
535 – 537	White clay and small gravel
537 – 568	Coarse white sand
568 – 720	Fine to medium gravel, streaks of white sandy clay and gray clay, fine to medium white sand
720 - ?	Fine gray, sandy silty clay

SM- 935
Surface Elevation: 59 feet above sea level

Depth (feet)	Description
0 – 101	?
101 – 126	Medium to coarse brown sand and gravel
126 – 132	Fine grey sand
132 – 138	Fine gray sand, gray to yellow clay strips
138 – 165	Fine gray sand
165 – 168	Brown to yellow clay
168 – 251	Brown fine sand, streaks of clay
251 – 254	Solid gray clay (hard)
254 – 265	Medium brown sand and mica
265 – 270	Brown sandy clay with streaks of black clay
270 – 308	Brown sand streaks of gray clay and hardpan
308 – 310	Gray clay
310 – 313	Fine gray sand, lignite , mica
313 – 330	Gray hard clay, hardpan
330 – 344	Fine gray sand, clay strips
334 – 365	Gray clay
365 – 373	Gray clay, streaks of fine gray sand and lignite
373 – 383	Gray clay (hard)
383 – 405	Fine gray sand with streaks of gray clay and pyrite
405 – 408	Dark clay with big pieces of pyrite
408 – 491	Fine gray sand, gray clay strips
491 – 501	Brown clay with streaks of medium brown sand and small grits
501 – 540	Brown sand and grits with streaks of clay and sandy clay
540 – 542	Gray clay
542 – 555	Fine gray sand, gray clay strips
555 – 561	Medium gray sand and gravel
561 – 563	Gray solid clay
563 – 594	Coarse sand and gravel with some white clay
594 – 595	White clay
595 – 601	Medium sand and grits with streaks of white clay
601 – 602	Coarse sand and gravel
602 – 605	White clay
605 – 620	Medium to coarse white sand with grits and gravel and streaks of clay
620 – 622	White clay
622 - ?	White sand and grits

Hallock Ave
Surface Elevation: 53 feet above sea level

Depth (feet)	Description
0 – 2	Top soil
2 – 28	Coarse sand and gravel
28 – 35	Very fine brown sand
35 – 70	Silty fine gray sand with mica
70 – 195	Solid and sticky grey clay
195 – 197	Solid and sandy grey clay with some sand, hardpan and grits
197 – 228	Solid grey clay
228 – 233	Fine to coarse brown sand, mica, and hardpan
233- 243	Brown and grey sandy clay with brown sand and grits
243 – 271	Coarse grey sand with gravel, stones and rocks
271 – 296	Solid pinkish brown clay (drills hard)
296 – 307	Solid and sandy pinkish brown clay with grits
307 – 348	Solid brown clay
348 – 408	Fine to coarse brown sand and grits with mica
408 – 425	Coarse brown sand and gravel
425 – 461	Fine to medium brown sand
461 – 500	Medium brown sand and gravel
500 – 552	Fine to medium reddish brown sand and mica
552 – 568	Coarse red sand, gravel, and stones
568 – 571	Solid multicolored clay
571 – 575	Solid and sandy multicolored clay with gravel and large stones
575 – 663	Fine to coarse sand, grits, gravel and some clay with embedded white gravel up to 1.5’’
663 – 666	Solid and sandy grey clay and grey clayey sand
666 – 681	Fine to coarse brown sand, grits, gravel
681 – 685	Solid and sandy grey clay and grey clayey sand
685 – 701	Fine to coarse brown sand, grits, gravel, and mica
701 - ?	Solid white clay