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Geology Report

Project: Bostic Creek Jurisdictional Ditch 16 / Jurisdictional Ditch 28 Stabilization Project.

Purpose: As part of the Bostic / Zippel Watershed assessment; portions of both watersheds were identified as having the potential of causing excess sedimentation to Lake of the Woods. The goal of this investigation is to study the potential for stabilizing one portion of the Bostic Creek Ditch that is currently exhibiting the highest erosion rates.

Location: Lake of the Woods County, MN

Present: Tim Weisbrod, NRCS Geologist and Scott Swanberg, NRCS Engineer.

Date of investigation: September 3, 2013



Figure 1-Map of the Bostic / Zippel watershed with the proposed treatment area in the Bostic Creek watershed highlighted in orange.

Background

The following introductory text is from the Bostic / Zippel Watershed Assessment Final Report written in January of 2013:

Bostic and Zippel watersheds are located in Lake of the Woods County and are 36,380 acres and 63,440 acres in size respectively. See Figure 1. The watersheds are approximately 15 miles northwest of the county seat of Baudette, population 1,106 (2010 census). Both watersheds drain in a northeast direction and outlet into the Lake of the Woods through Four Mile (Bostic) and Zippel Bays. The Canadian Pacific Railroad and Minnesota State Highway 11 run parallel to each other in a northwest to southeast direction across the upper third of both watersheds. Williams, population 191 (2010 census) is the largest city within the study area. It is located on Williams Creek within the Zippel Creek watershed along State Highway 11. The small community of Graceton is located along State Highway 11 near Canfield Creek within the Bostic Creek watershed.

The character of each watershed's topography and soils is largely due to events that occurred during the last glacial period. Approximately 13,000 years ago, much of Manitoba, northwestern Ontario, northern Minnesota, and eastern North Dakota were covered by an immense glacial meltwater lake known as Glacial Lake Agassiz. When the glaciers finally retreated and meltwater drained, it left behind a series of large sandy beach ridges in Lake of the Woods County. The most prominent northwest to southeast beach ridge within the study area is known as Campbell Beach. This beach ridge bisects both Bostic and Zippel watersheds creating a distinct land form separation. State Highway 11 runs approximately 1 mile south and parallel to this beach ridge. The watershed north of the beach ridge is part of the Glacial Lake Agassiz near shore lake bottom with a gentle slope toward the Lake of the Woods. Wave action during the retreat of Glacial Lake Agassiz was responsible for smoothing out the landscape north of the beach ridge. During this period depressions were filled in and knolls leveled leaving much of area with poor natural drainage. Channels in this area were shallow waterways with well-defined floodplains.

With the pre-settlement landscape, runoff would flow out of the upland bog/marsh areas then down through the beach ridge within well-defined channel systems (Tomato Creek, Williams Creek, and Canfield Creek). Downstream of the beach ridge, the channels would enter the extensive peat bogs then seep out before exiting into Lake of Woods. Since flow patterns downstream of the beach ridge were not very distinct or direct, this type of landscape would tend to "meter" out the runoff.

The initial drainage efforts of the early 1900's were met with limited success. In the 1930's however, drier conditions, widespread fires on forest land and organic soils, improved dredging equipment, need for improved roads/transportation, and a rapid development of county wide agricultural economy saw the large scale drainage of the watersheds improve. Also, in 1966, an NRCS/SCS PL-566 Watershed Protection Project in the Zippel Creek watershed consisting of over 16 miles of large surface ditches was installed.

Currently, Lake of the Woods County serves as the authority for the ditches within the county and is responsible for repairs and maintenance.

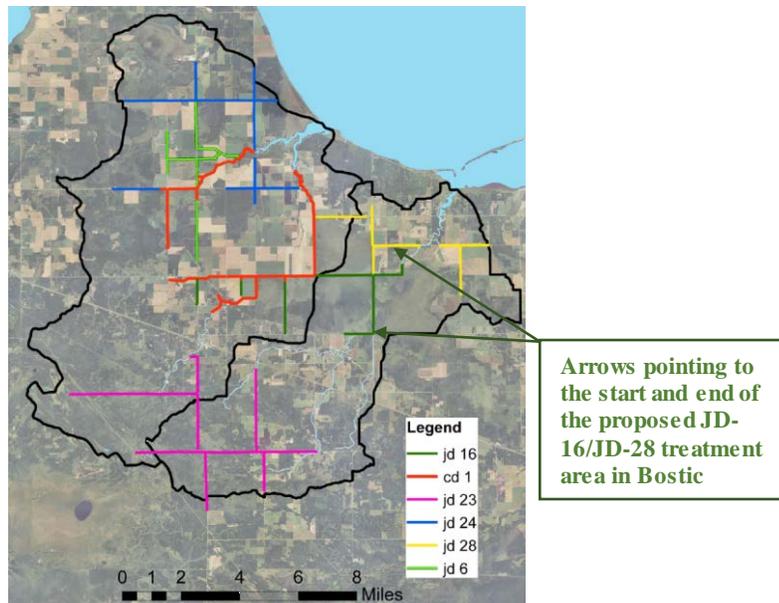


Figure 2- Map showing the current County and Jurisdictional ditches located in the Bostic and Zippel watersheds.

The current plan is to work with the county and the local SWCD to create an engineering plan for these projects.

The above referenced sediment study ended with the publication of the Bostic & Zippel Creeks Watershed Assessment report in January, 2013. The report identified critical reaches of Bostic Creek whose stabilization would most effectively benefit Bostic Bay. Based on the report mentioned above, Lake of the Woods County requested NRCS design assistance in stabilizing some of these reaches.

Site Geology

Based on the Minnesota Geological Survey maps the depth to bedrock in the watershed is between zero and one hundred feet. Although, there are likely areas near the site with the bedrock close to the surface, glacial sedimentary geology is the primary geologic influence on this watershed. Most of the surficial sediments in this area were deposited in the quaternary time period by a series of glacial events associated with continental glaciation of the Laurentide Ice sheet. The cold climate that created the glaciers fluctuated much like the weather does today. This created a series of glacial advances during cold times and glacial retreats as the weather warmed. Overtime, as the glaciers advanced and retreated across the landscape they deposited sediment based on the source area that they advanced across. As the glaciers melted they deposited the sediment that was ground up and transported with the glacier during its advance. This deposited material was called glacial till. As the glaciers continued to melt, they retreated to the north, creating large glacial rivers which carried sediment away from the melting glacier and deposited the

sorted coarse grained sediment in outwash plains. These glacial rivers were occasionally blocked to form meltwater lakes like Glacial Lake Benson and Glacial Lake Agassiz in front of the retreating glacier. As mentioned in the introduction, the sediment deposits in the watershed have been modified by Glacial Lake Agassiz. After the glaciers retreated there has been 7,000-10,000 years of erosion occurring on the landscape which further moved and re-deposited sediment as colluvium and alluvium. This created the pre-ditch stream network. Because of the complex geologic history described above, the soil parent material on the site is a mix of interlayered glacial till, sandy near shore lacustrine deposits, clayey lacustrine deposits, and highly organic soils formed in historical low spots in the landscape (figure 3).

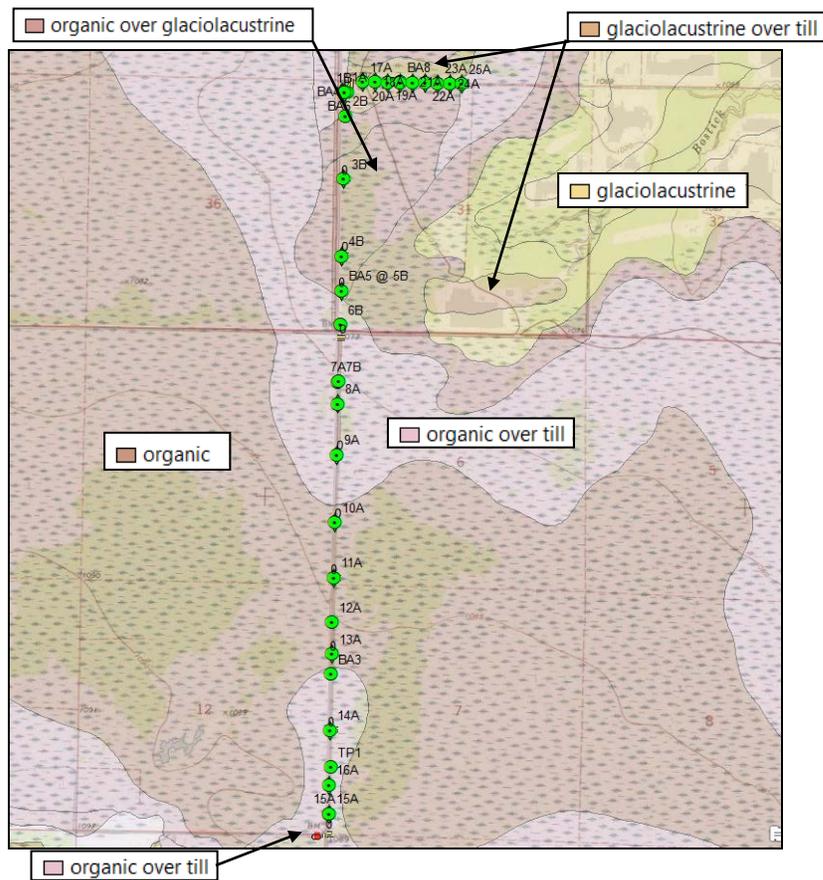


Figure 3- Soils parent material map of the portion of the JD-16/JD-28 ditch that we are currently focusing on for this report.

Watershed based Interpretations

The goal of this section of the report is to discuss some of the geologic and anthropogenic factors that may be leading to erosion in the EQIP application area of the watershed. The complex geologic history described above has also influenced the topography and drainage of the watershed. Most of the watershed that is currently draining to Bostic Creek has always drained in that direction. But, because the landscape is relatively young in geologic terms it did not have a well-developed drainage network when settlers first came

to the area. Historic topography maps from 1954 show a lot of poorly drained areas that are more conducive to groundwater recharge instead of surface runoff and drainage (figure 4).

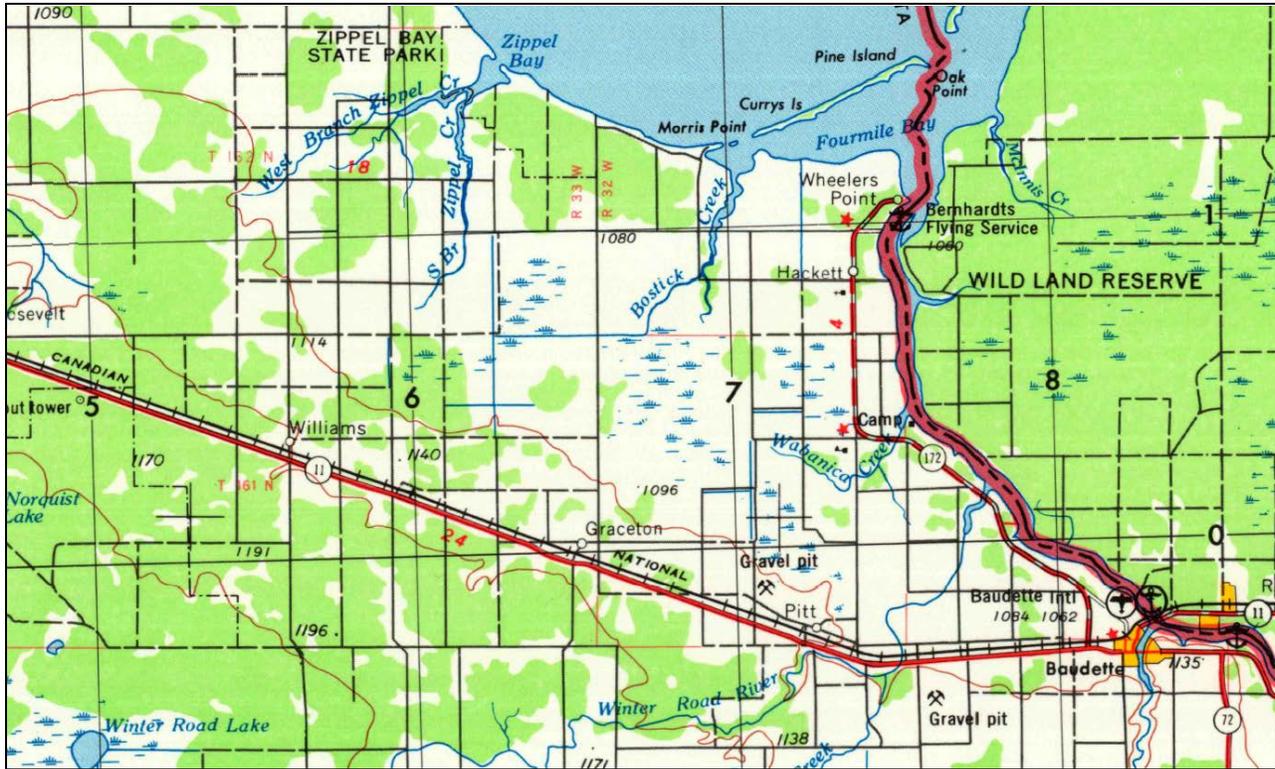
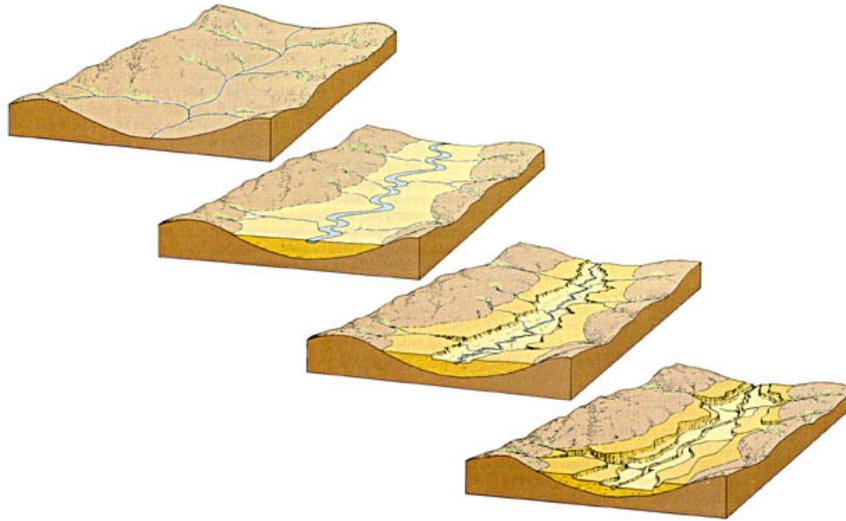


Figure 4- Historic USGS Topographical map of project area made in 1954. This was made prior to the construction of the JD-16/JD-28 ditch. A majority of the Bostick/Zippel watersheds are covered by wetlands and flat topography with steeper beach ridge on the south-western edge of the watersheds.

Over a long period of time the drainage network will naturally developed in the best places to drain the landscape. Figure 5 shows a simplified example of landscape evolution through time. In this example, the landscape is steepened and eroded by head ward erosion from the bottom of the watershed upward to compensate for a change in the base level of the stream outlet. As it is steepened rills and gullies continue to work their way up into the upland. The 1954 topographic map of the site (Figure 4) shows that this same process may have started in all of the natural draws on the edge of Lake of the Woods after the glaciers and Glacial Lake Agassiz had receded. The base level of Bostick Creek is being controlled by variations in water level at the dam on the north end of Lake of the Woods. So as long as the dam on the northern edge of Lake of the Woods is in place Bostick creek will not evolve to the level shown in figure 5. But it will see some adjustments due to anthropogenic changes in lake water level, watershed drainage area, and the drainage ditch systems.

Young



Mature

Figure 5- Simplified example of landscape evolution. As the larger river matures over time, it erodes and causes additional down cutting and erosion in the smaller tributaries as they adjust to the change in grade. This process steepens the watershed and increases the runoff from the upland.

In natural systems, the rate at which landscapes evolve is very slow and typically does not cause rapid sedimentation in the downstream areas. In the JD-16/JD-28 example it took 7,000-10,000 years for the landscape to evolve to what is seen on the 1954 topographic map (figure 4). But, when people installed the ditches to improve surface drainage for farming purposes we changed the drainage system. After the installation of the ditch and the introduction of farming to the watershed, the upper portions of the watershed behaves a lot more like a mature well-developed drainage system. This is because the well connected, straight ditches bypass the natural storage that used to exist in the system. So, more of the runoff from the upland fields is reaching the main ditch faster than it ever did in the past. To compound this further we have also increased the runoff in the uplands by converting to row crop agriculture. Based on information gathered during the writing of the Bostic / Zipple Sediment Budget; I believe these changes in watershed conditions are causing changes in flow conditions of the original stream system and forcing it to adjust.

During the Bostic / Zipple watershed analysis, a stream power GIS layer was overlain with a sediment erosion potential GIS layer to create a layer which estimates potential erosion in the watersheds. Based on this analysis the JD-16/JD-28 portion of the watershed has a very high potential for erosion. This makes it a good area to target to reduce sedimentation to the Lake of the Woods.

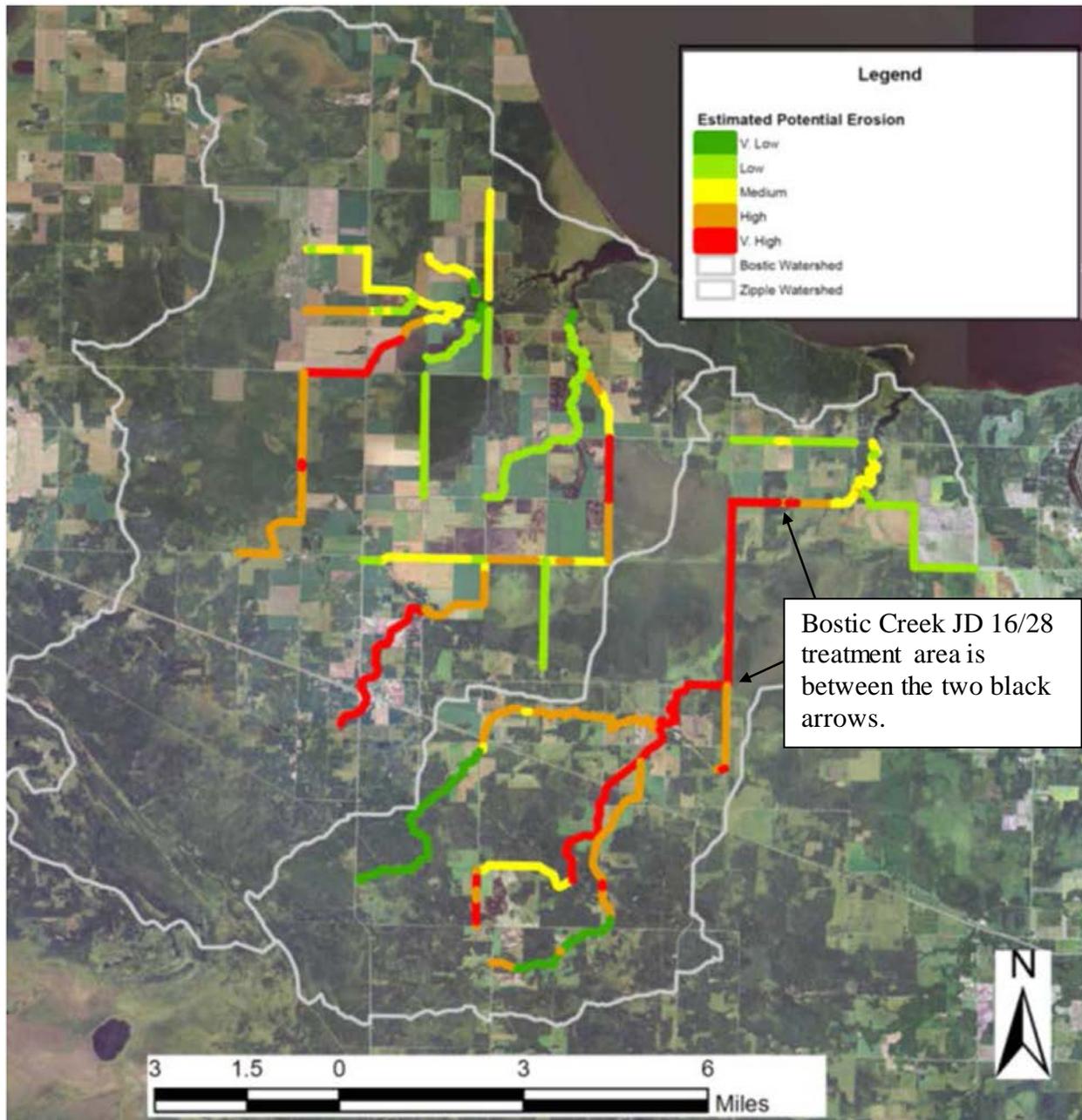


Figure 6 – Map of estimated potential erosion in the Bostic / Zipple watersheds. Bostic Creek JD-16/JD28 treatment area is between the two black arrows.

Geomorphic conditions in the JD-16/JD-28 portion of Bostic Creek.

As mentioned in the previous section I believe changes in watershed conditions are causing changes in flow conditions of the original stream system and forcing it to adjust. Adjustment to streams can occur in many different ways but two common adjustments we see in streams are from degradation and aggradation. Degradation is the process of streams eroding sediment and aggradation is the process of depositing sediment. In 1955, Lane developed the Lane's Balance model to explain how these processes typically work

for any given location in a stream system (figure 7). The water flow properties such as slope and the Discharge (Q) of water are on the right hand side of the balance. The Discharge equals the cross sectional area of the stream at a given flow times the velocity. A given rainfall event in the watershed will create a certain discharge. As the cross sectional area decreases and the stream is restricted like it is in a constructed ditch the velocity will increase creating erosion. Sediment transport properties such as sediment size and the amount of sediment being transported are on the left hand side. Increase in flow velocity can cause increased erosion upstream which can cause an increase in the sediment load.

As you increase the amount of water, decrease the cross sectional area, or the slope of the stream the balance tips to the right and you have more degradation or erosion in the stream. As you increase the amount and size of sediment being transported in the stream beyond what the stream can transport the sediment is deposited. Using a general understanding of Lane's Balance and our understanding of the changes in the watershed you would predict an overall increase in degradation in the watershed. Our investigation of the JD-16 portion of the Bostic creek ditch system verifies this. It seemed like erosion is more common than deposition in all parts of the ditch system we walked except the outlet into the Lake of the Woods where the slope gets very flat.

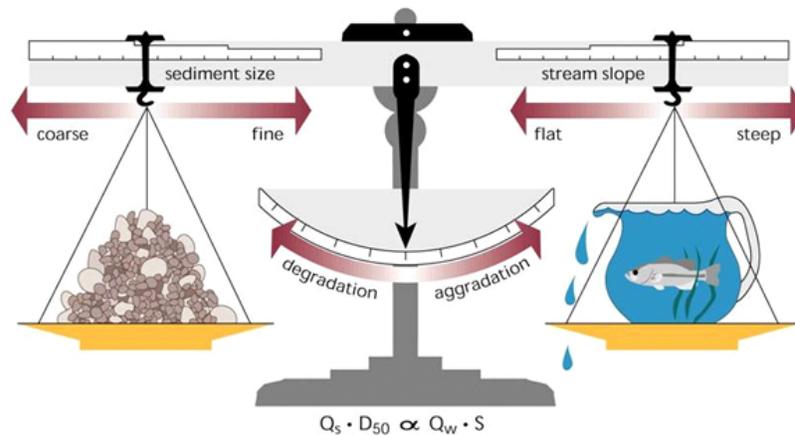


Figure 7- Lane's Balance.

Another useful means of analyzing a stream is with Simon's Channel Evolution Model (figures 8 and 9). This model takes the concepts of aggradation and degradation one step further and applies it to how a stream system adjusts after a disturbance event that increases the water flow side of the lanes balance equation. As shown in figure 9, the Simon stages usually vary across the longitudinal profile. Stage I is the pre-modified condition (pre-ditch). Stage II is the modified condition (creation of the ditch). Stage III is degradation otherwise known as down cutting of the channel. Typically the degradation occurs as a gully head (also known as a knickpoint) is moving upstream setting a less steep grade of the streams' longitudinal profile. The gully head (also known as a knickpoint) continues to degrade and begins to widen. Stage IV begins to occur as degradation and widening of the channel creates an unstable side slope. The gully moves upstream until a stable profile is reached. The downstream areas begin to aggrade and fill

in as the channel widens enough to start reducing the stream power allowing increases in deposition. Stage V begins to occur as aggradation and widening creates a large sediment load which begins to outweigh the strength of the flow. This typically happens in the lower portion of the watershed when the slope of the stream becomes less steep and the cross section has widened the most. Stage VI is a temporarily stable point known as the Quasi Equilibrium. This typically occurs when a stream has established an equilibrium with the environment. This is commonly achieved in a stream that is well connected to the floodplain, allowing the cross sectional area to widen and create lower velocities during large rain events which cause high discharges.

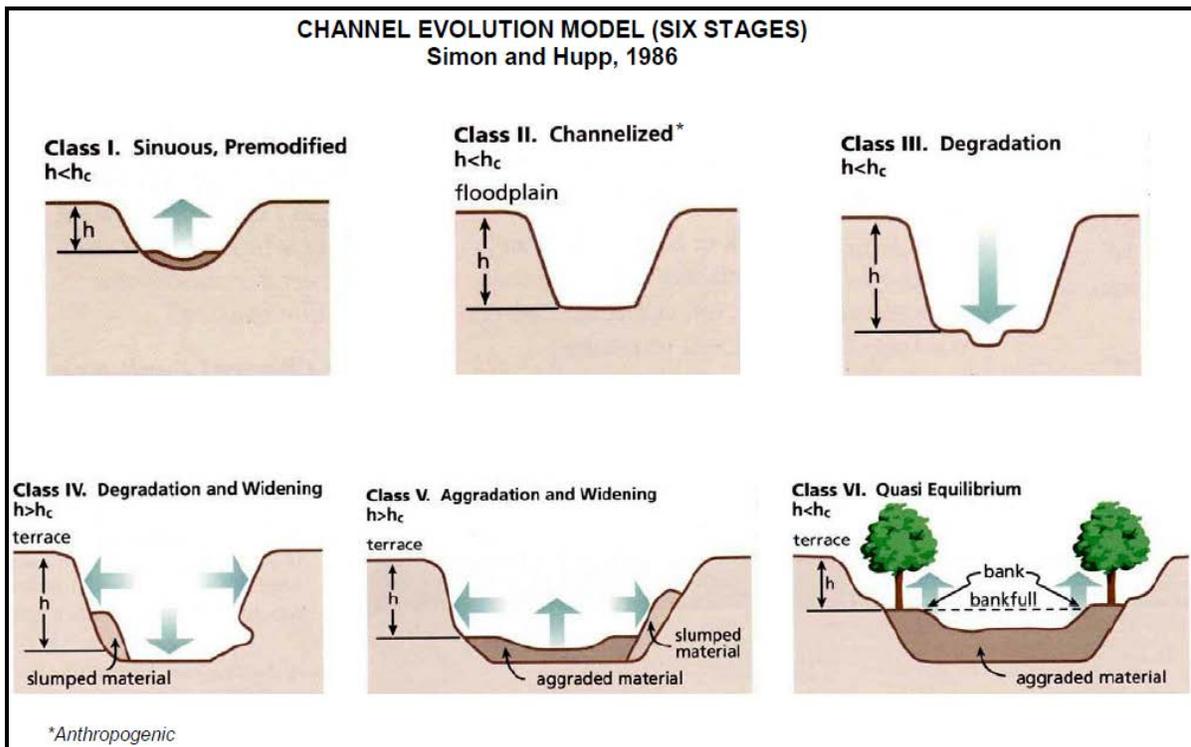


Figure 8- Cross Sectional view of the Channel Evolution Model (Modified from Simon and Hupp, 1986).

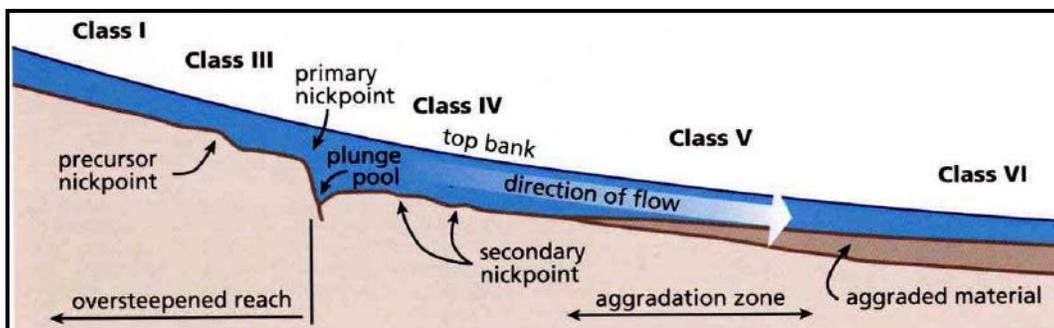


Figure 9 – Profile view of the Channel Evolution Model (Modified from Simon and Huopp, 1986).

Figure 10 is a surveyed profile showing the estimated Simon Channel Evolution Model classifications determined based on our walks across the site and while looking at the survey profile and cross section data. Two potential knick points (also known as gullies)

have been identified on the profile which indicate current and likely future degradation in that portion of the ditch system.

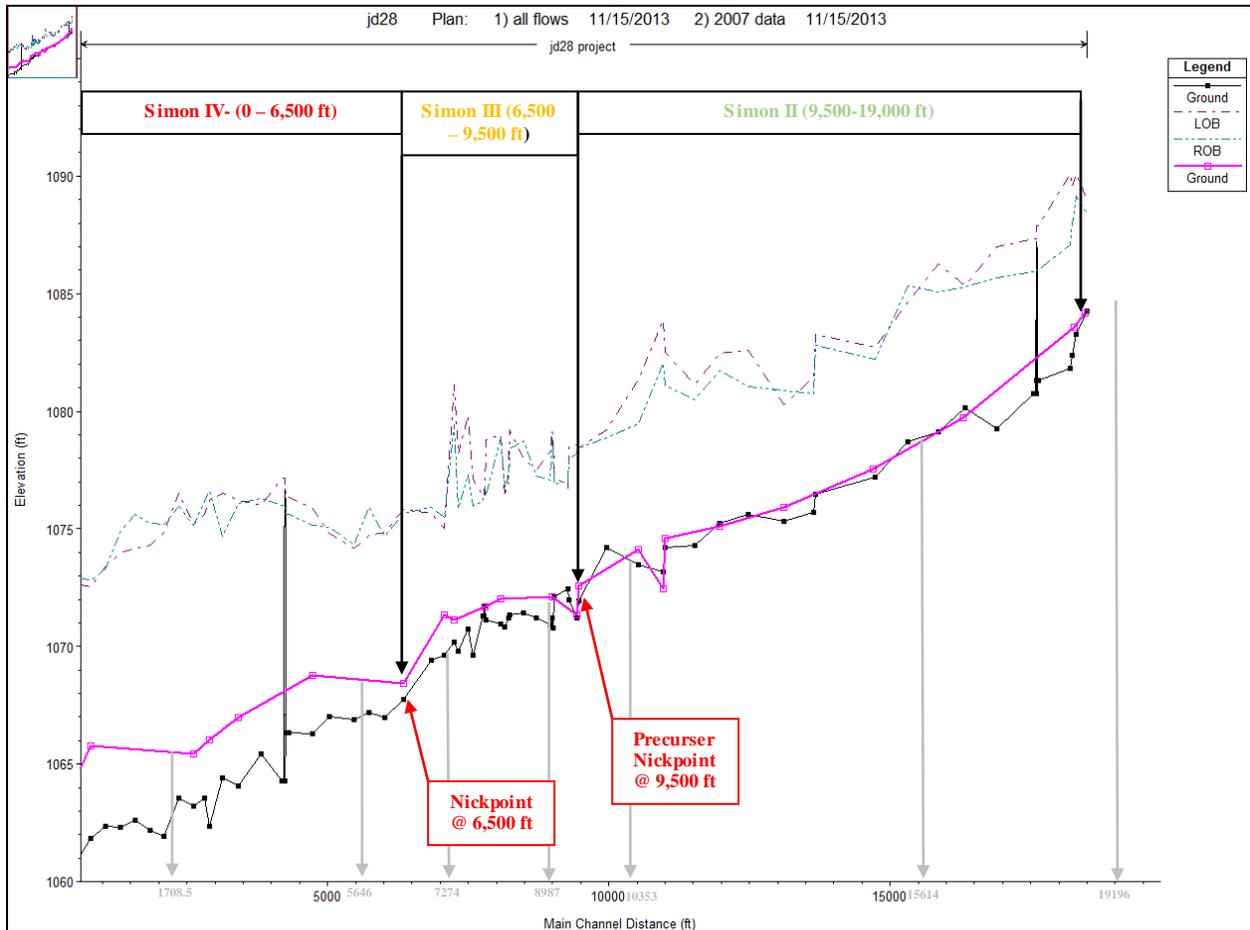


Figure 10- Surveied profile showing the survey from 2013 in black and the survey from 2007 in pink. The reach is subdivided based on the interpreted Simon CEM classification. Two interpreted nick points have been identified in red. The locations of cross sections discussed later in the text are shown in gray.

Figure 11 depicts the interpreted Simon CEM classification shown in figure 10 on a plan view map. The locations of the representative cross sections discussed later in the text have a black rectangle around them. The rest of this section of the report will use the representative cross sections to explain the Simon CEM classifications portrayed in figures 10 and 11. It is recommended that the reader cross references these figures while reading the rest of the text in this section.



Figure 11 – Map of the EQIP application area showing the currently assumed Simon Channel Evolution Model (CEM) classification based on the information viewed in the field. The locations of cross sections discussed later in the text are shown in the black rectangle

As seen in the typical cross sections for the reach between station 0-6500 (figure 12 & 13), I believe this stretch is experiencing fairly significant adjustment by down cutting and widening associated with increased flow in the watershed or changes in the base level of the Lake. I believe this process is part of a watershed wide degradation process started by anthropogenic changes in the watershed / ditch system and / or changes in water level of Lake of the Woods creating changes in the base level of the stream. This stretch appears to be very unstable and has likely degraded a lot in the past (Simon CEM stage IV). The hydrology needs to be analyzed but I assume there is too much discharge for the size, shape, and slope of the channel. If this is the case, degradation and widening associated with increased flow in the watershed will continue and likely migrate upstream.

Stabilization attempts should include grade control and adjustment of ditch cross sectional area to create a meandering two stage ditch system.

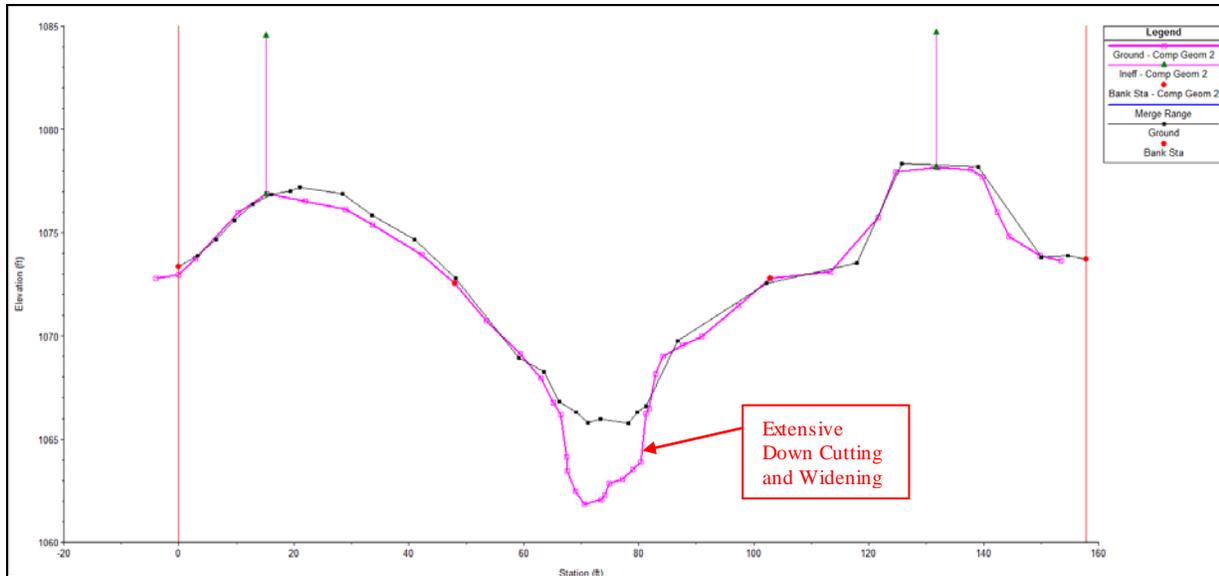


Figure 12- Typical cross section of the reach from 0-6500 ft taken at station 1708.5. Showing the survey in 2007 in black and 2013 in pink. Areas of extensive erosion are labeled in red.

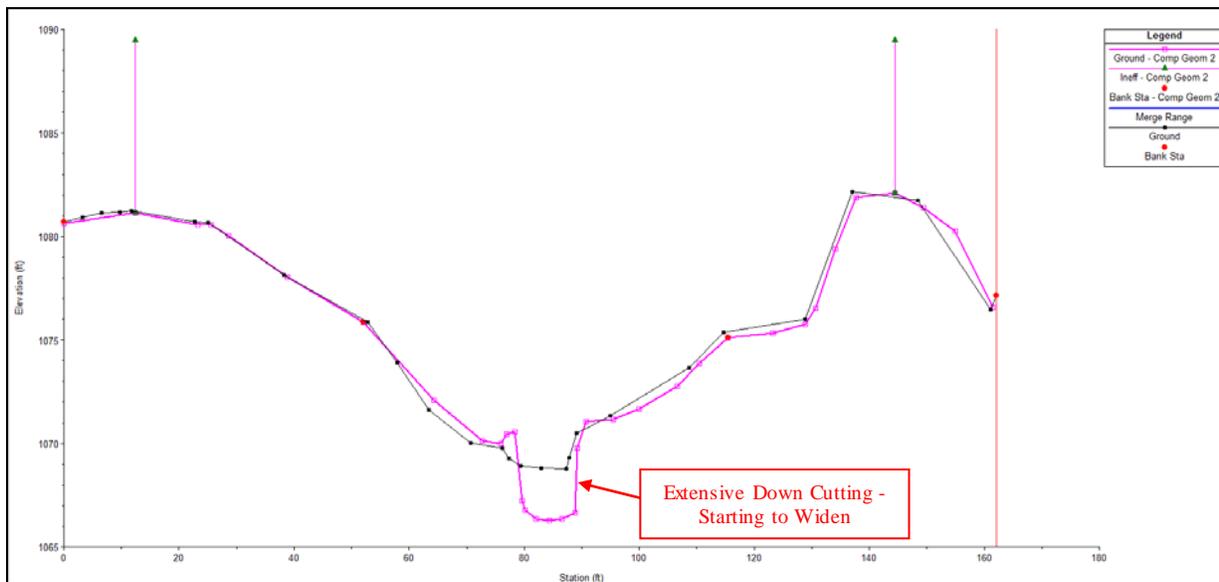


Figure 13- Typical cross section of the reach from 0-6500 ft taken at station 5646 ft. Showing the survey in 2007 in black and 2013 in pink. Areas of extensive erosion are labeled in red.

I believe this stretch will continue to degrade until a stable grade is reached the reach will then continue to widen until the angle of repose is reached for the material on the banks of the channel. I believe future widening of this ditch section will be exasperated by variable geologic conditions present on the ditch banks of this reach. This will be discussed in more detail later in the geotechnical portion of the report.

As seen in the typical cross sections for the reach between station 6500-9500 (figure 14 and figure 15), this reach appear to be very unstable and has likely been down cutting a lot in the past (Simon CEM stage III). The hydrology needs to be analyzed but I assume there is too much discharge for the size, shape, and slope of the channel. If this is this case degradation and widening associated with increased flow in the watershed will continue creating a Simon CEM stage IV reach. Stabilization attempts should include grade control and widening of the ditch to create a meandering two stage ditch as shown in red on figures 14 and 15.

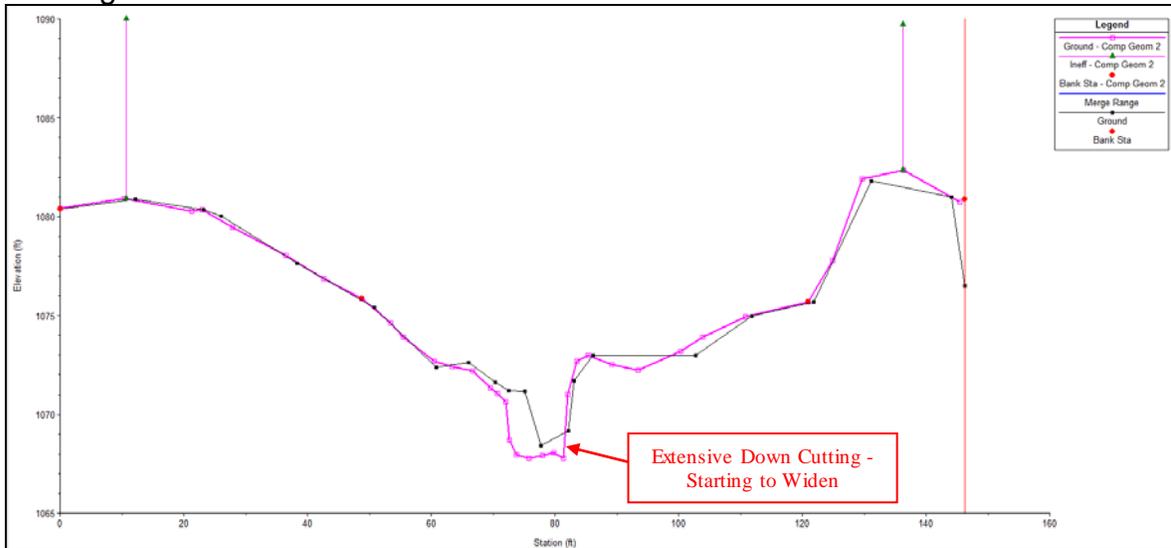


Figure 14- Typical cross section of the reach from 6500-9500 ft taken at station 7274 ft. Showing the survey in 2007 in black and 2013 in pink. Areas of extensive erosion are labeled in red.

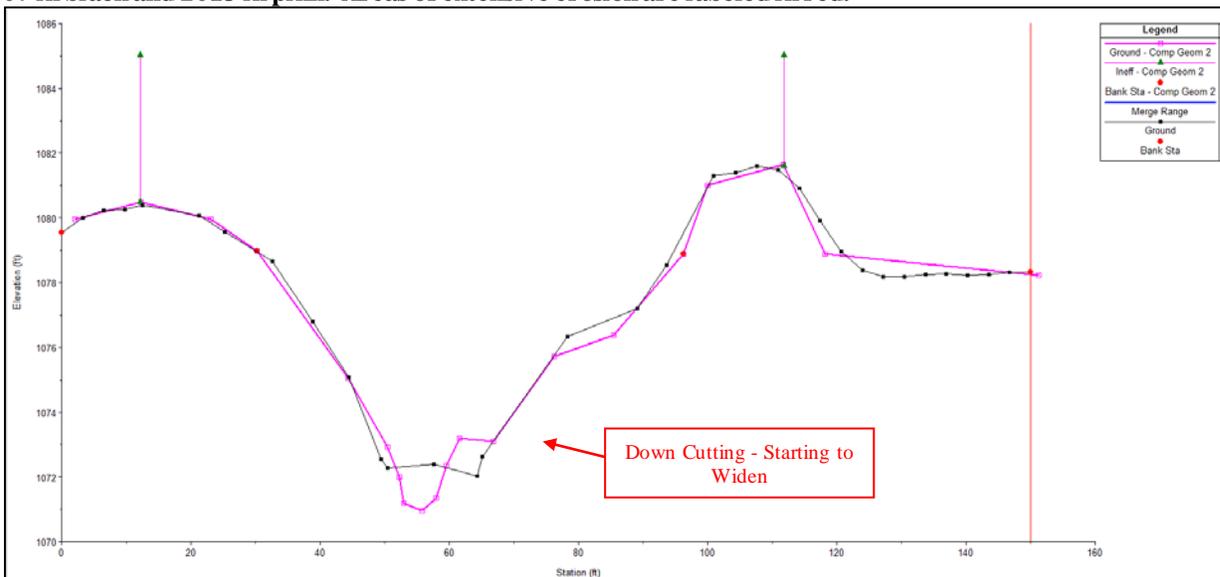


Figure 15- Typical cross section of the reach from 6500-9500 ft taken at station 8987 ft. Showing the survey in 2007 in black and 2013 in pink. Areas of extensive erosion are labeled in red.

As seen in the typical cross sections for the reach between station 9500-19388 (figure 16 - 19), although there are places with localized stream bank erosion this reach appear to be stable (Simon CEM stage II). But if left unprotected by grade control on the lower portions of this reach I believe the gully will continue to work up from downstream and destabilize

this portion of the stream eventually. In my opinion a new stable longitudinal profile grade needs to be established using some type of grade control. A stable cross-sectional area and grade will need to be estimated using the hydrology of the site.

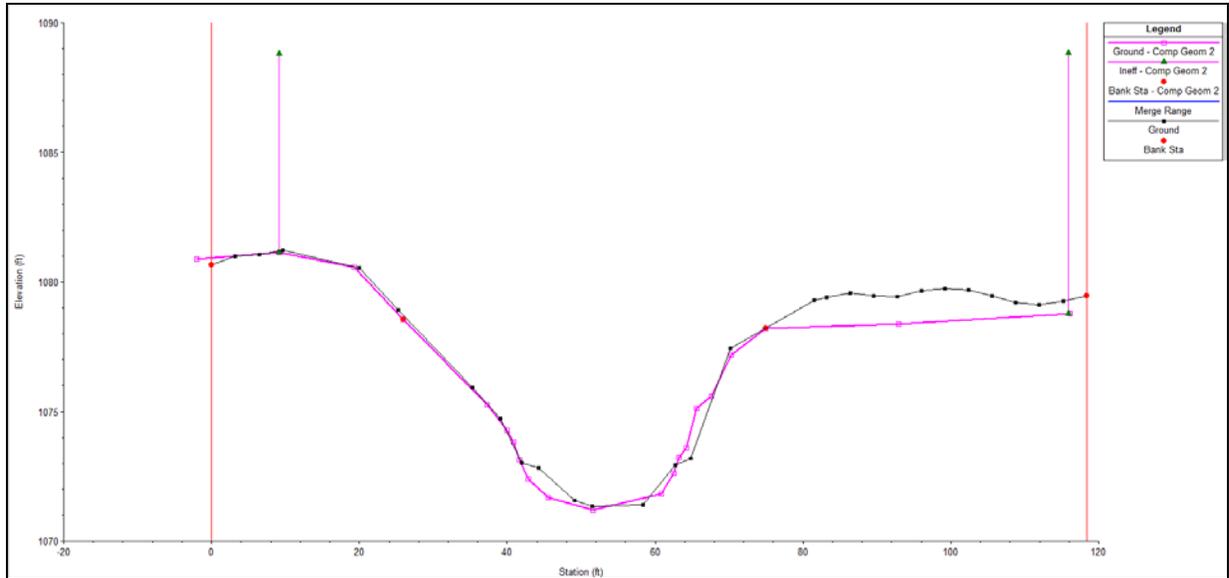


Figure 16 - Typical cross section of the reach from 9500-19388 ft taken at station 10353 ft. Showing the survey in 2007 in black and 2013 in pink. This reach appears to be stable.

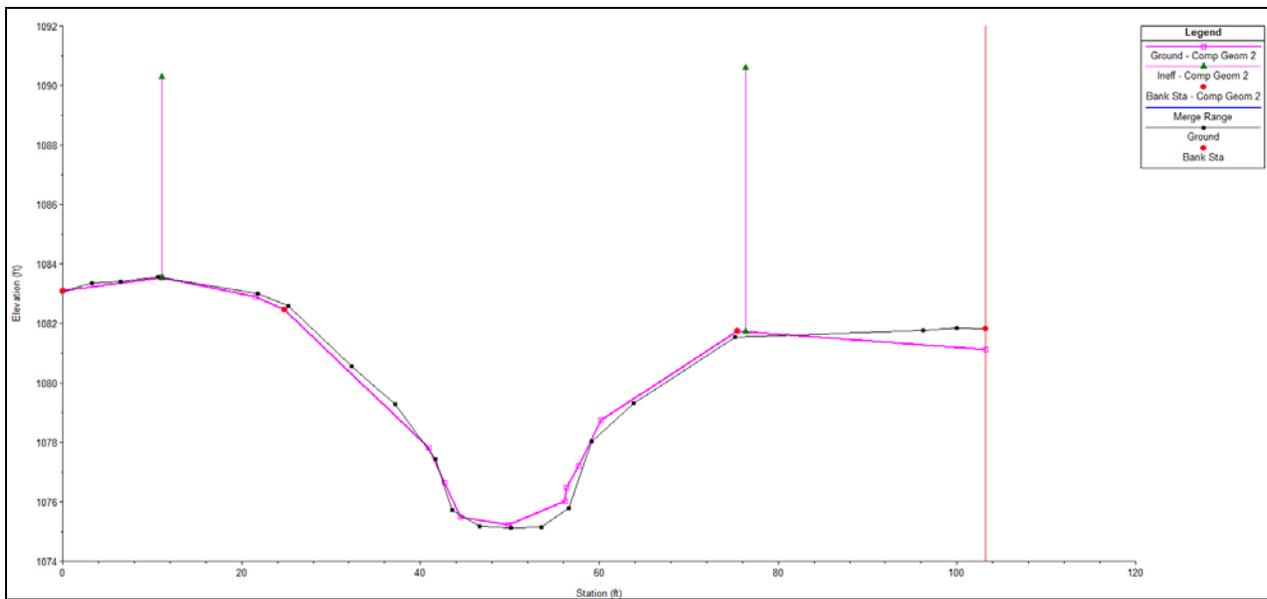


Figure 17 - Typical cross section of the reach from 9500-19388 ft taken at station 10353 ft. Showing the survey in 2007 in black and 2013 in pink. This reach appears to be stable.

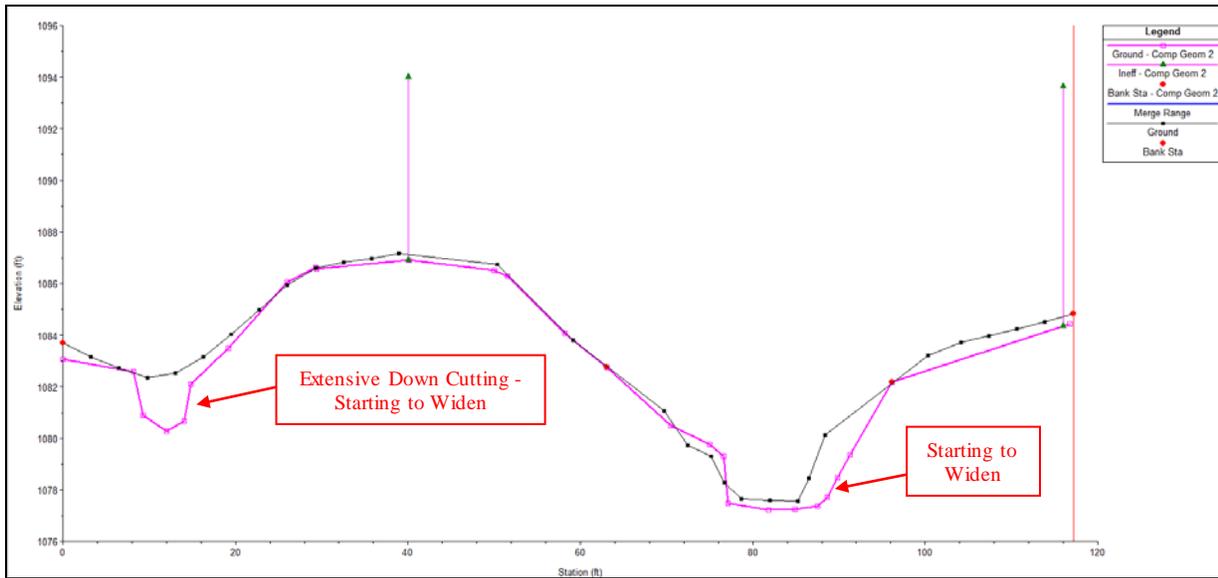


Figure 18 - Typical cross section of the reach from 9500-19388 ft taken at station 15614 ft. Showing the survey in 2007 in black and 2013 in pink. Areas of extensive localized erosion are labeled in red. But overall the reach is stable.

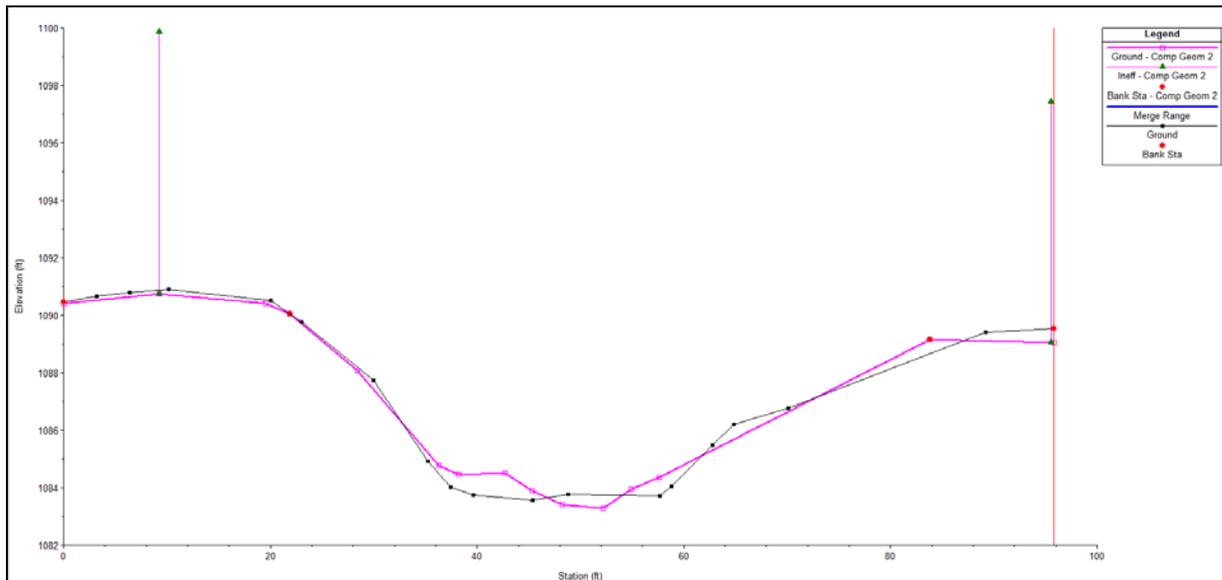


Figure 19 – Typical cross section of the reach from 9500-19388 ft taken at station 19196 ft. Showing the survey in 2007 in black and 2013 in pink. This reach appears to be fairly stable.

Preliminary Geotechnical Investigation

Walks through this portion of the ditch system have shown that variations in geology across the site may also be contributing to the variations in erosion rates seen in this stretch. So in September of 2013; Scott S. and Tim W. met at the site and did a preliminary soils investigation. As mentioned in the geology section of this report, the site is a mix of glacial till, near and offshore glacial lake sediments, and organic layers. The

investigation consisted of a series of hand auger borings used to gain a preliminary understanding of the geology on the site. The investigation results were summarized in figure 20, 21, and 22 based on boring logs and cross sections included in Appendix B and Appendix C. Based on the geologic investigation the geology of this site can be lumped into two different zones.

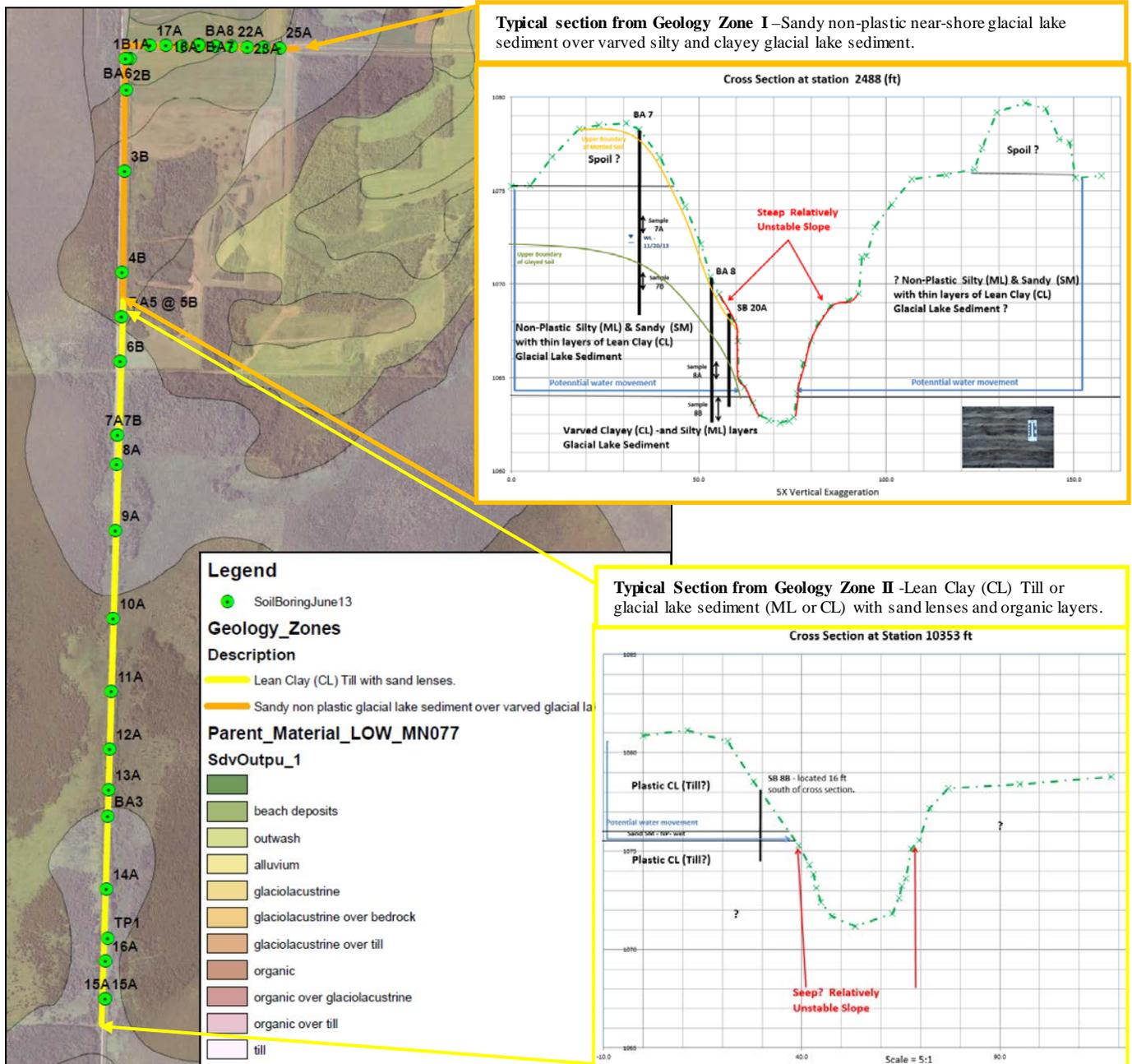


Figure 20- Map of studied reach divided into two geology zones based on the results of the geologic investigation.

As seen in figure 20 and 21; Geology Zone 1 goes from station 0 to around station 7500. As seen in the typical cross section at station 2488 (figure 20, figure 21, Appendix B, and Appendix C), this area is comprised of non-plastic sandy or silty near-shore glacial lake

deposits (SM and ML) over clayey and silty varved off-shore glacial lake deposits (ML layered with CL-CH). This variable geology creates a high potential for seepage at the intersection between the near-shore and off-shore glacial lake sediments. The horizontal layers of clay within the varved off-shore deposits forces water to move laterally creating the potential of increased seepage on the upper edge of the off-shore deposits as noted on the cross sections. The other disadvantage of the geology on this zone is the low structural strength associated with the ML portion of horizontally layered varved off-shore glacial lake sediments. As a result, the bottom of the stream in this geology zone is a lot more prone to down cutting and erosion than it initially appeared.

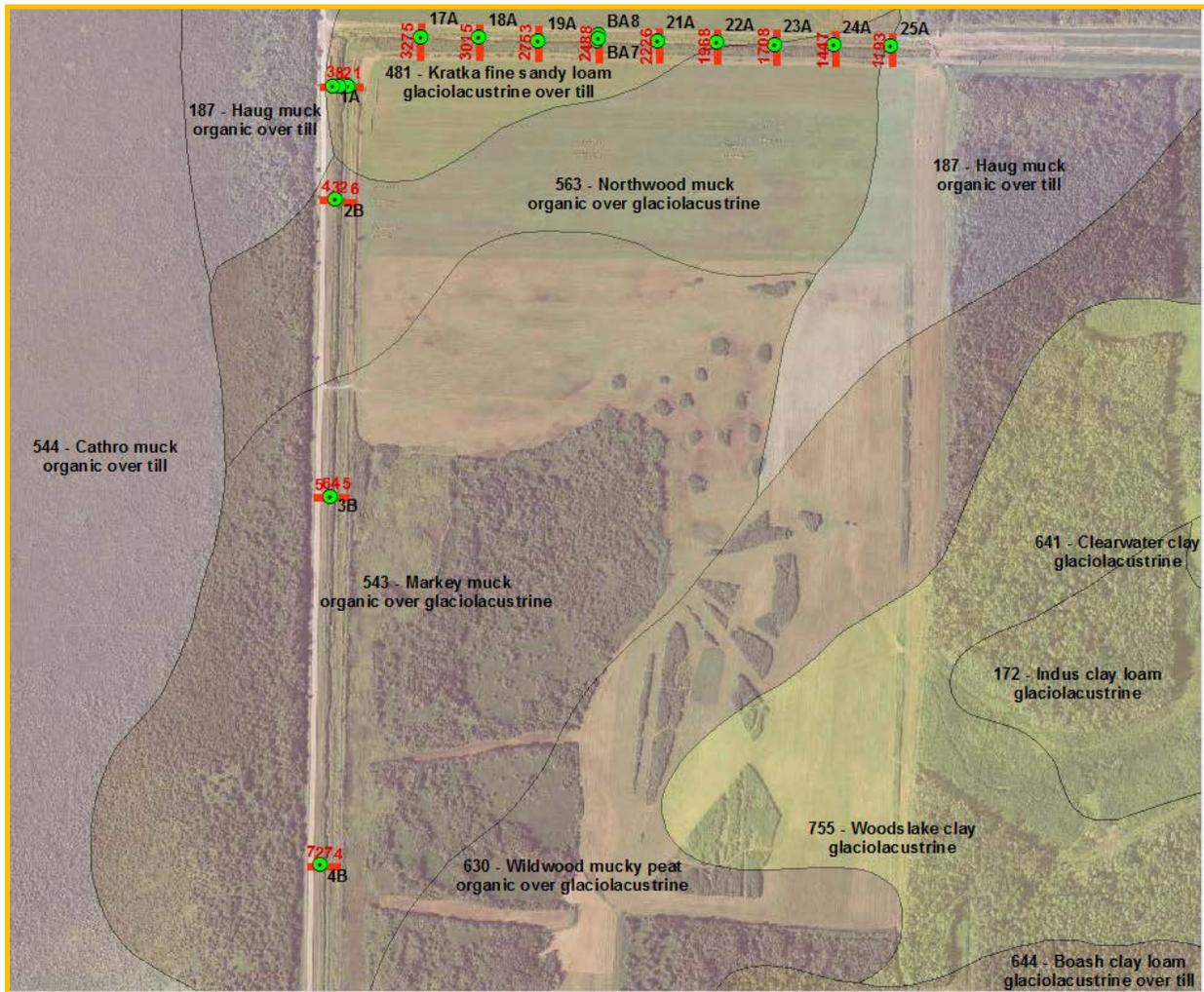


Figure 21- Map showing the SURGO soil with parent materials, the cross sections in red, and soil borings in green within “Geology Group I”. The cross-sections in this portion of the area all resemble the Geology Group I Typical cross section from station 2488 as seen in figure 20. Most of the cross sections in this group showed a similar pattern of non-plastic sandy or silty near-shore glacial lake deposits over clayey and silty varved off-shore glacial lake deposits (Appendix C).

As seen in figure 20 and 21; Geology Zone 2 goes from station 7500 to around station 18000. As seen in the typical cross section at station 10353 (figure 20, figure 21, Appendix B, and Appendix C), this area is comprised of plastic Lean Clay (CL) or Silty

(ML) sediment either deposited as glacial till or glacial lake sediment with small (<1 ft) sand layers and / or organic layers identified in some of the cross sections (Appendix C).

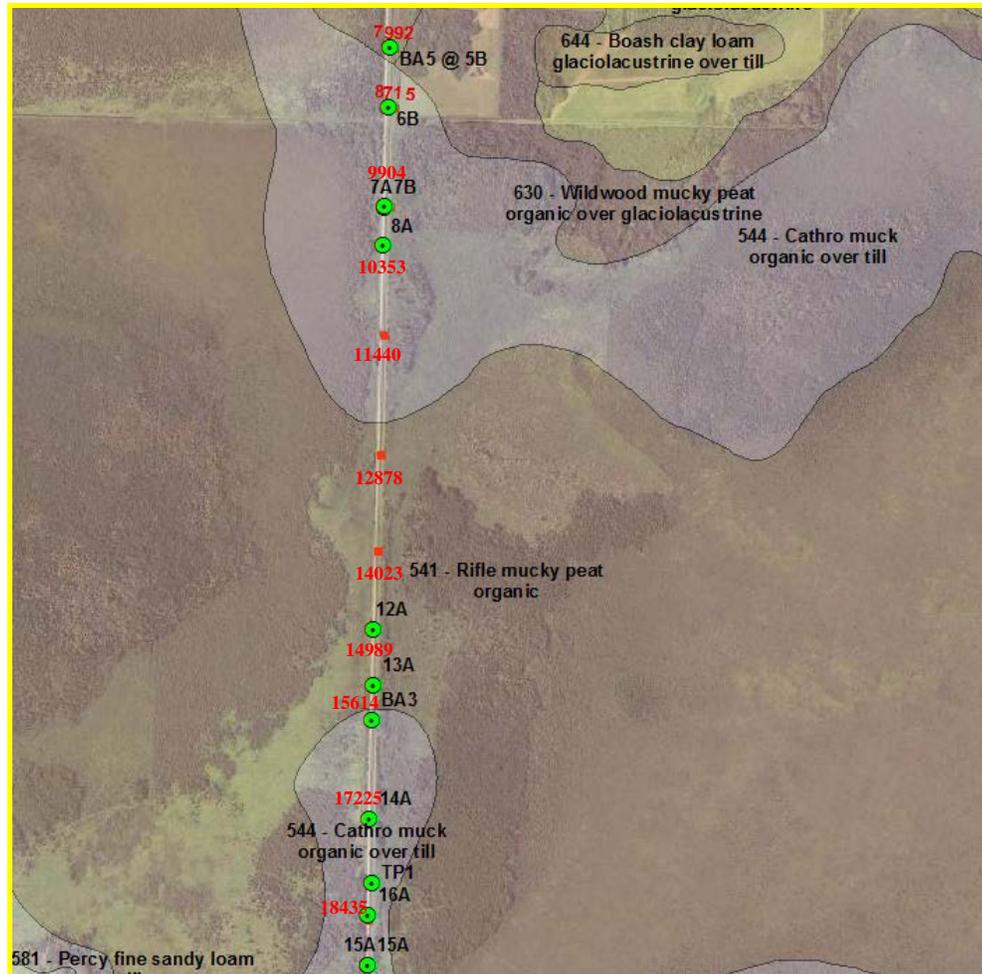


Figure 22- Map showing the SURGO soil with parent materials, the cross sections in red, and soil borings in green within “Geology Group II”. The cross-sections in this portion of the area all resemble the Geology Group II typical cross section from station 10353 as seen in figure 20. Most of the cross sections in this group showed a similar pattern of plastic Lean Clay (CL) or silty (ML) sediment either deposited as glacial till or glacial lake sediment with small (<1 ft) sand layers and / or organic layers identified in some of the cross sections (Appendix C).

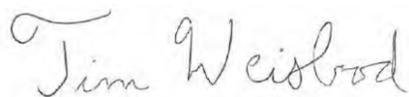
Summary and Recommendations:

After a disturbance to the stream that causes degradation, the goal is to re-establish the Quasi-Equilibrium conditions. To do this you typically have to create a stable stream pattern (meander belt width), longitudinal profile (slope), and cross section (with good connection to a floodplain). I propose that the next step is to have a hydrologist use a hydraulic model to estimate flows and model different scenerios. This will help us re-design and stabilize parts of the ditch in a more geomorphically stable manner. This may mean widening the top width and creating a meandering two stage system in the upper reaches (which stores sediment and reduces flow velocity) and creating a stable grade and

stabilizing select stream banks in the rest of the area. Typically stream bank stabilization does not work alone in an area that is degrading (III) or widening (IV) because the toe slope can easily fail as the stream down cuts. So we may have to stabilize the longitudinal profile within the degrading (Simon CEM III) and widening (Simon CEM IV) areas first by adding grade control to the ditch in those areas to stabilize the grade. Because of these complexities it is important that one considers the Simon Channel Evolution Model Classification while determining the proper stabilization techniques. As a supplement to Wisconsin Practice Standard 580: Stream Bank Stabilization a chart was created to help people use stream classification to stabilize stream banks (Appendix A). I recommend that we treat the EQIP application area using a modified version of Appendix A.

Once the grade is set the unstable portions of the stream which were labeled as Simon CEM class III or IV in figure 11, may need to have the toe of the slope stabilized to reduce the chance of future widening. Part of the widening may need to include dewatering. In geology zone I, this would need to be done on the boundary between the non-plastic silty or sandy (SM or ML) material and the varved clayey and silty (CL layered with ML) glacial lake sediment. In geology zone II dewatering should take place on sand lenses that may discharge water at the toe of the slope. The full extent of the sand lenses in geology zone II is not fully constrained so if any structural measures are planned in this zone additional soil borings should take place in the locations of those structural treatments.

Submitted September 16, 2015 by:



Tim Weisbrod
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Rochester, MN

References Cited:

Bostic & Zippel Creeks Watershed Assessment, Lake of the Woods County, Minnesota; Written January

2013. See the following embedded PDF:



GIS data is available in the Geologic Investigation Layer Package file:

Geologic Investigation.lpk

Appendix A: WI Stream bank Stabilization (580) guidelines

TREATMENT STRATEGIES BASED ON CLASSIFICATION

Stream classification can be used not only to assess general trends in stream behavior but also to provide a guide to the selection of treatment strategies. The two tables provided below have been developed as such a guide*. Since every stream system is unique, these are only general trends and there are certainly exceptions.

Treatment Strategies Based on Stream Classification for Low Banks (< 8 ft.)

Simon CEM Stage	Rosgen Classification	Treatment Strategies	Typical Practices ¹
I Stable ²	C, E	Maintain existing watershed runoff volumes and patterns and sediment loads. Maintain or improve existing riparian corridor vegetation. May need to implement soil bioengineering in isolated spots.	Spot treatments with fascines, live stakes, seedlings, rooted stock, or grasses.
III Down-cutting	Gc	Reduce watershed runoff and sediment loads. May need to raise channel bottom to reconnect stream to floodplain and reestablish sinuosity, or may need to establish grade control structurally. May need to reestablish or improve riparian corridor vegetation, DO NOT IMPLEMENT SOIL BIOENGINEERING ALONE.	May need to either fill channel and realign or install grade control; then whatever soil bioengineering is required.
Early IV Widening and down-cutting	F	May need to reduce watershed runoff and sediment loads. May need to create more floodplain (excavation) and shape banks enough to place toe protection. May need to reestablish or improve riparian corridor vegetation. DO NOT IMPLEMENT SOIL BIOENGINEERING ALONE.	May require minor grading with permanent toe protection; then whatever soil bioengineering is required.
IV ³ Widening w/o down-cutting	C, E ³	Maintain existing watershed runoff volumes and patterns and sediment loads. Reestablish or improve existing riparian corridor vegetation. Consider physically modifying channel width. May need to shape banks enough to place temporary toe protection. Implement soil bioengineering where needed.	May require minor grading with temporary toe protection; then whatever soil bioengineering is required.
Late IV Widening	F, Bc	Maintain existing watershed runoff and sediment loads. May need to create more floodplain (excavation) and shape banks enough to place toe protection. May need to reestablish or improve riparian corridor vegetation. DO NOT IMPLEMENT SOIL BIOENGINEERING ALONE.	Minor grading with permanent toe protection; then whatever soil bioengineering is required.
Early V Deposition	F, Bc	Maintain existing watershed runoff and sediment loads. May need to create more floodplain (excavation) and shape banks enough to place toe protection. Improve riparian corridor vegetation. Implement soil bioengineering where needed.	Minor grading with permanent toe protection; then whatever soil bioengineering is required.
Late V Deposition	Bc, C, E	Maintain existing watershed runoff and sediment loads. May need to shape some banks enough to place toe protection. Improve riparian corridor vegetation. Implement soil bioengineering where needed,	Minor grading with permanent toe protection; then whatever soil bioengineering is required.
VI Stable ²	C, E	Maintain existing watershed runoff volumes and patterns and sediment loads. Maintain or improve existing riparian corridor vegetation. May need to implement soil bioengineering in isolated spots.	Spot treatments with fascines, live stakes, seedlings, rooted stock, or grasses.

Treatment Strategies Based on Stream Classification* for High Banks (≥ 8 ft.)

Simon CEM Stage	Rosgen Classification	Treatment Strategies	Typical Practices ¹
I Stable ²	C, E	Maintain existing watershed runoff volumes, patterns and sediment loads. Maintain or improve existing riparian corridor vegetation. May need to implement soil bioengineering an isolated spots.	Spot treatments with fascines, live stakes, seedlings, rooted stock, or grasses.
III Down- cutting	Gc	Reduce watershed runoff and sediment loads. Raise channel bottom to reconnect stream to floodplain and reestablish sinuosity, or establish grade control structurally. May need to reestablish or improve riparian corridor vegetation. DO NOT IMPLEMENT SOIL BIOENGINEERING ALONE.	Either fill channel and realign or install grade control; then whatever soil bioengineering is required.
Early IV Widening and down-cutting	F	Reduce watershed runoff and sediment loads. Create more floodplain (excavation) and shape banks to reduce slope failure hazard and place toe protection. May need to reestablish or improve riparian corridor vegetation. DO NOT IMPLEMENT SOIL BIOENGINEERING ALONE.	Major grading with permanent toe protection; then whatever soil bioengineering is required.
IV ³ Widening w/o down- cutting ³	C, E ³	Maintain existing watershed runoff volumes, patterns and sediment loads. Reestablish or improve existing riparian corridor vegetation. Consider physically modifying channel width. May need to shape banks enough to reduce slope failure hazard and to place temporary toe protection. Implement soil bioengineering where needed.	May require grading with temporary toe protection; then whatever soil bioengineering is required.
Late IV Widening	F, Bc	Maintain existing watershed runoff and sediment loads. Create more floodplain (excavation) and shape banks to reduce slope failure hazard and place toe protection. May need to reestablish or improve riparian corridor vegetation. DO NOT IMPLEMENT SOIL BIOENGINEERING ALONE.	Major grading with permanent toe protection; then whatever soil bioengineering is required.
Early V Deposition	F, Bc	Maintain existing watershed runoff and sediment loads. May need to create more floodplain (excavation) and shape some banks to reduce slope failure hazard and to place toe protection. Improve riparian corridor vegetation. Implement soil bioengineering where needed.	Minor grading with permanent toe protection then whatever soil bioengineering is required.
Late V Deposition	Bc, C, E	Maintain existing watershed runoff and sediment loads. May need to shape some banks to reduce slope failure hazard and to place toe protection. Improve riparian corridor vegetation. Implement soil bioengineering where needed.	Minor grading with permanent toe protection then whatever soil bioengineering is required.
VI Stable ²	C, E	Maintain existing watershed runoff volumes, patterns and sediment loads. Maintain or improve existing riparian corridor vegetation. May need to implement soil bioengineering in isolated spots.	Spot treatments with fascines, live stakes, seedlings, rooted stock, or grasses.

¹ Most soil bioengineering practices will be placed on the active floodplain above the top of the low streambanks. Some practices may be placed on the upper part of the bank.

² Stable from a geomorphic perspective.

³ "C" or "E" stream types with higher width/depth ratios than the norm, and with accelerated streambank erosion rates, may be in Stage III due to loss or deterioration of riparian corridor vegetation.

*Based on information provided by Lyle J. Steffen, retired Geologist, USDA-NRCS, Lincoln, NE.

Appendix B – Soil Boring Logs

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 10A

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 2.4 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
5				<p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, Dark Gray (10yr 4/1), moist, low to medium plasticity, slightly firm. 5% gravel</p>	
10				<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low to medium plasticity; soft to firm. 5% gravel 2.4 feet - end of boring. Refusal from firm sediment.</p>	



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 11A

Surface Elevation: 1080.426

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.7 Coordinates(UTM): North - 1166960.48 East - 2208213.839

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
	[Hatched Pattern]			<p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT SC - Clayey Sand, Dark Gray (10yr 4/1), moist, low to medium plasticity, slightly firm. 5% gravel. 1/2 inch layers of SP present.</p>	
	[Hatched Pattern]			<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low to medium plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
				<p>3.7 feet - end of boring. Refusal from firm sediment.</p>	
5					1085
10					1090



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 12A

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 4.5 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
5	[Hatched Box]			<p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, Dark Gray (10yr 4/1), moist, low to medium plasticity, slightly firm. 5% gravel. 1/2 inch layers of SP present.</p>	
				<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low to medium plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
				<p>GLEYED PALE BROWN GLACIAL TILL CL - Lean Clay, Gleyed greenish gray (Gley 1 5/5gy); slightly moist to moist; low to medium plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
				<p>4.5 feet - end of boring. Refusal from firm sediment.</p>	
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 13A

Surface Elevation:

Exploration Equipment: Backsaver

Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.9 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
5				<p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, Dark Gray (10yr 4/1), moist, low to medium plasticity, slightly firm. 5% gravel. 1/2 inch layers of SP present.</p>	
				<p>HEMIC PEAT PT - Black (10yr 2/1) Hemic Peat with some visible root fibers and little or no mineral matter (only partially decomposed).</p>	
				<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low to medium plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
10				<p>3.9 feet - end of boring. Refusal from firm sediment.</p>	



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

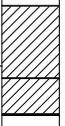
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 14A

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 2.4 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>NO RETURN</p>	
				<p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, Dark Gray (10yr 4/1), moist, low to medium plasticity, slightly firm. 5% gravel. 1/2 inch layers of SP present.</p>	
				<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low to medium plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
5				<p>2.4 feet - end of boring. Refusal from firm sediment.</p>	
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

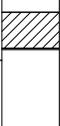
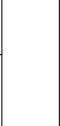
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 15A

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 2.9 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>TOPSOIL ML - Black (10yr 2/1) Silt with high organic matter and some roots present.</p>	
				<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low to medium plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
				<p>SAND LAYER SP-SM - Poorly graded sand with silt; brown (10yr 5/3)</p>	
				<p>NO RETURN</p>	
				<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low plasticity; soft to firm. 5% gravel.</p>	
5				<p>2.9 feet - end of boring. Refusal from firm sediment.</p>	
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 16A

Surface Elevation:

Exploration Equipment: Backsaver

Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
	▨			<p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, Dark Gray (10yr 4/1), moist, low to medium plasticity, slightly firm. 5% gravel. 1/2 inch layers of SP present.</p>	
	▨			<p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with gray (10yr 6/1) reduced areas and dark yellowish brown iron concentrations (10yr 4/6); slightly moist to moist; low plasticity (medium ribbon); soft to firm. 5% gravel.</p>	
				<p>3.0 feet - end of boring. Refusal from firm sediment.</p>	
5					
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 17A

Surface Elevation: 1069.671

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 5 Coordinates(UTM): North - 1177370.475 East - 2208812.087

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				SILTY GLACIAL LAKE SEDIMENT ML - Dark gray (10yr 4/1) silt with 10yr 3/6 concentrations, moist, non-plasticity, soft.	1070
				SILTY AND SANDY GLACIAL LAKE SEDIMENT ML with sand - Pale Brown (10yr 6/3)Sandy Silt; with gray (10yr 6/1) reduced areas and yellowish brown concentrations (10yr 5/6); very moist, non-plastic, very soft and loose.	
				CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and black (10 yr 2/1), moist, low to medium plasticity, firm, platy structure.	
5				5.0 feet - end of boring. no refusal.	1075
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 18A

Surface Elevation: 1068.724

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 5 Coordinates(UTM): North - 1177369.448 East - 2209072.393

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				SILTY GLACIAL LAKE SEDIMENT ML - Dark gray (10yr 4/1) silt, moist, slightly to non-plastic, soft.	1070
				SILTY GLACIAL LAKE SEDIMENT ML - Dark gray (10yr 4/1) silt, moist, non-plastic, soft.	
				SILTY AND SANDY GLACIAL LAKE SEDIMENT ML - Dark gray (10yr 4/1) silt with laminated layers of fine sand, moist, non-plastic, soft.	
5				5.0 feet - end of boring. no refusal.	
10					1075

Report: ULEN LOG | Project: BZ_C4_LOGS_7-19-13.GPJ | Data Template: USDA-NM-2005.GDT | Last Mod: 31 Jul 2013 09:47 am | Printed: 16 Sep 2015 11:52 am



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

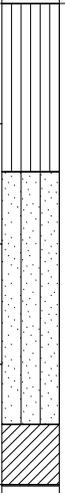
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 19A

Surface Elevation: 1067.969

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 4 Coordinates(UTM): North - 1177353.216 East - 2209333.889

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Grayish Brown (10yr 5/2) silt with gray (10yr 6/1) reduced areas and yellowish brown (10yr 5/8) concentrations, moist, slightly to non-plastic, soft.</p>	
				<p>SANDY GLACIAL LAKE SEDIMENT SM - gray (10yr 6/1) silt with Light Gray (10yr 7/2) reduced areas and yellowish brown (10yr 5/8) concentrations, moist, slightly to non-plastic, very soft.</p>	1070
				<p>CLAYEY GLACIAL LAKE SEDIMENT CL - Gray (10yr 5/1) lean clay, moist, low plasticity, firm.</p>	
				<p>4.0 feet - end of boring. no refusal.</p>	
5					
10					1075



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 1A

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 2.7 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>TOPSOIL ML-Silt , Black (10 yr 2/1), slightly moist to dry, slightly plastic to non-plastic, granular structure, and slightly firm.</p> <p>GLACIAL LAKE SEDIMENT SM - Silty sand, dark greyish brown (10yr 4/2), slightly moist to dry, non-plastic, and firm.</p> <p>GLACIAL LAKE SEDIMENT SM - Silty sand, yellowish brown (10yr 5/4), slightly moist, non-plastic, soft to slightly firm.</p> <p>2.7 feet - end of boring. Refusal from firm sediment.</p>	
5					
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 1B

Surface Elevation: 1069.615

Exploration Equipment: Backsaver Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 5 Coordinates(UTM): North - 1177150.319 East - 2208454.56

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				GLACIAL LAKE SEDIMENT ML-CL - Silty clay, dark grey (10yr 4/1), slightly moist to moist, slightly plastic to low plasticity, soft to slightly firm.	1070
				SANDY GLACIAL LAKE SEDIMENT SM - Silty Sand; brown (10yr 5/3) with light brownish gray (10yr 6/2) reduced areas and dark yellowish brown concentrations (10yr 3/5); very moist, non-plastic, soft and loose.	
				SANDY GLACIAL LAKE SEDIMENT SM - Silty Sand; Gleyed Green (gley 1 5/10g), very moist, non-plastic, soft and loose.	
				SILTY GLACIAL LAKE SEDIMENT ML - Silt, Gleyed Green (gley 1 5/10 g), very moist, slightly to non plastic, soft, stratified.	
5				CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and very dark gray (10 yr 3/1), moist, low to medium plasticity, very firm, platy. 5.0 feet - end of boring. no refusal.	1075
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

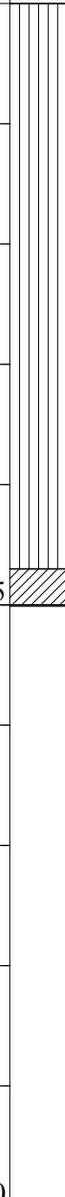
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 20A

Surface Elevation: 1068.377

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 5 Coordinates(UTM): North - 1177357.027 East - 2209595.004

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
10				<p>SILTY GLACIAL LAKE SEDIMENT ML - Dark Grayish Brown (10yr 4/2) silt, moist, slightly to non-plastic, soft. turns very wet and get mottling with depth.</p>	1070
				<p>CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and black (10 yr 2/1), moist, low to medium plasticity, slightly firm, platy structure. 5.0 feet - end of boring. no refusal.</p>	1075



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

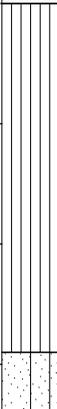
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 21A

Surface Elevation: 1069.19

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.3 Coordinates(UTM): North - 1177355.58 East - 2209859.583

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Dark Grayish Brown (10yr 4/2) silt with gray (10yr 6/1) reduced material and dark yellowish brown (10yr 4/6) concentrations, moist, slightly to non-plastic, soft. turns very wet and get mottling with depth. Increasing sand with depth until it is an ML with sand.</p>	1070
				<p>SANDY GLACIAL LAKE SEDIMENTS SM - SP - Brown (10yr 5/3) poorly graded sand with silt. non-plastic. slightly firm.</p>	
				<p>3.4 feet - end of boring. Refusal firm sediment.</p>	
5					
10					1075



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 22A

Surface Elevation: 1069.045

Exploration Equipment: Backsaver

Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.8 Coordinates(UTM): North - 1177347.828 East - 2210118.624

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Very Dark Grayish Brown (10yr 3/2) silt, moist, non-plastic, soft.</p>	1070
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Very Pale Brown (10yr 7/3) silt with light gray reduced areas (10yr 7/2) and dark yellowish brown(10yr 4/6) concentrations, dry becomes moist with depth, non-plastic, soft. Layered platy structure.</p>	
				<p>CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and black (10 yr 2/1), moist, low to medium plasticity, slightly firm, platy structure. 3.8 feet - end of boring. Refusal due to firm sediment.</p>	1075
5					
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 23A

Surface Elevation: 1069.115

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 5 Coordinates(UTM): North - 1177340.797 East - 2210375.946

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Dark Grayish Brown (10yr 4/2) silt with light brownish gray (10yr 6/2) reduced areas and dark yellowish brown (10 yr 3/6) concentrations, slightly moist to moist, non-plastic.</p>	1070
				<p>HEMIC PEAT PT - Black (10yr 2/1) Hemic Peat with some visible root fibers and little or no mineral matter (only partially decomposed). NO RECOVERY</p>	
				<p>CLAYEY GLACIAL LAKE SEDIMENTS CL - Greenish Black Lean clay (Gley 2 - 2.5 / 10G), moist, low to medium plasticity, firm, some horizontal layering and platy structure.</p>	
5				<p>5.0 feet - end of boring. Refusal due to firm sediment.</p>	1075
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

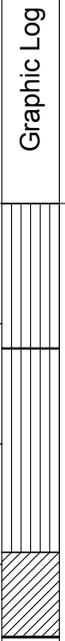
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 24A

Surface Elevation: 1068.274

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.6 Coordinates(UTM): North - 1177338.414 East - 2210634.871

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Dark Grayish Brown (10yr 4/2) silt, slightly moist to moist, non-plastic.</p> <p>Seasonal High Water Table @ 1.2 feet.</p>	1070
5				<p>CLAYEY GLACIAL LAKE SEDIMENTS CL - Greenish Black Lean clay (Gley 2 - 2.5 / 10G), moist to very moist, low plasticity, firm.</p> <p>3.6 feet - end of boring. Refusal due to firm sediment.</p>	1075
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

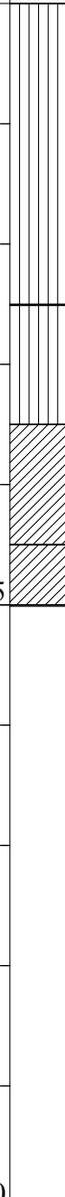
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 25A

Surface Elevation: 1070.051

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 5 Coordinates(UTM): North - 1177334.039 East - 2210889.765

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>SILTY GLACIAL LAKE SEDIMENT ML - Dark Grayish Brown (10yr 4/2) silt, slightly moist to moist, non-plastic.</p> <p>Seasonal High Water Table @ 2.5 feet.</p> <p>CLAYEY GLACIAL LAKE SEDIMENT CL - Yellowish Brown (10yr 5/4) lean clay intensely mottled with gray (10yr 5/1) reduced areas and dark yellowish brown (10 yr 3/6) concentrations, moist, low to medium plasticity, good ribbon.</p> <p>GLEYED CLAYEY GLACIAL LAKE SEDIMENTS CL - Dark Greenish Gray Lean clay (Gley 2 - 4 / 5BG), moist to very moist, low plasticity, firm.</p> <p>5.0 feet - end of boring. No refusal.</p>	1075
10					1080



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 2B

Surface Elevation:

Exploration Equipment: Backsaver

Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.3 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				CLAYEY GLACIAL LAKE SEDIMENT CI - Lean clay, gray (10yr 5/1), moist to very moist, low plasticity, approx- 20% black (10 yr 2/1) decaying root material.	
				SANDY GLACIAL LAKE SEDIMENT ML - Silt with sand, grayish brown (10 yr 5/2) with gray (10 yr 5/1) reduced areas and dark yellowish brown (10 yr 4/6), slightly moist, non plastic, soft.	
				CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and very dark gray (10 yr 3/1), moist, low to medium plasticity, very firm, platy.	
				3.3 feet - end of boring. Refusal from firm soil.	
5					
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 3B

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 3 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				CLAYEY GLACIAL LAKE SEDIMENT CI - Lean clay, dark gray (10yr 4/1), moist to very moist, low plasticity, lots of root material, soft to slightly firm.	
				SANDY GLACIAL LAKE SEDIMENT SM - Silty sand, yellowish brown (10 yr 5/4), slightly moist, non plastic, soft to slightly firm.	
				CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and very dark gray (10 yr 3/1), moist, low to medium plasticity, very firm, platy.	
				3.0 feet - end of boring. Refusal from firm sediment.	

5

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Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 4B

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 4.3 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>CLAYEY GLACIAL LAKE SEDIMENT CI - Lean clay, dark gray (10yr 4/1), moist to very moist, low plasticity, lots of root material, soft to slightly firm.</p>	
				<p>SANDY GLACIAL LAKE SEDIMENT ML- silt with sand, yellowish brown (10 yr 5/4) with gray (10yr 6/1) concentrations and dark yellowish brown (10 yr 4/6) concentrations, slightly moist, non plastic, soft to slightly firm. Sand reduces with depth and it becomes an ML.</p>	
				<p>CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CL - Lean clay, varved alternating layers of gray (10 yr 5/1) and very dark gray (10 yr 3/1) with yellowish brown (10 yr 5/6) concentrations, moist, low to medium plasticity, very firm, platy. 4.3 feet - end of boring. Refusal from firm sediment.</p>	
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Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

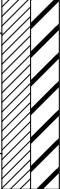
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 5B

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 4.8 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				CLAYEY GLACIAL LAKE SEDIMENT CI - Lean clay, dark grayish brown (10yr 4/2), moist, low plasticity, slightly firm.	
				CLAYEY GLACIAL LAKE SEDIMENTS CL-CH- Lean to fat clay, brown (10 yr 5/3), moist, medium plasticity, slightly firm.	
5				4.8 feet - end of boring. Refusal from firm sediment.	
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 7A

Surface Elevation:

Exploration Equipment: Backsaver

Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 4.3 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>TOPSOIL ML - Silt, very dark gray (10yr 3/2), slightly moist, slightly to non plastic, lots of roots.</p> <p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, dark gray (10yr 4/1) layered with light gray (10yr 7/2) silt layers and containing some brown (10yr 4/3) concentrations, slightly moist, slightly to low plasticity, and firm.</p> <p>LOSS</p> <p>DARK GRAY ORGANIC RICH TILL DERIVED LAKE SEDIMENT CL - Lean Clay, very dark gray (10yr 3/2), moist, slightly to low plasticity, slightly firm, with 5% rock fragments on average and increasing sand and gravel percentage (%) with depth. A few 1 inch sand (SP) lenses present with no evidence that they are water bearing during the investigation.</p> <p>PALE BROWN GLACIAL TILL CL - Lean Clay, pale brown (10yr 6/3) with light gray (10yr 7/2) and greenish gray gleyed material mixed in, moist, low plasticity, 5% rock fragments.</p> <p>BROWN GLACIAL TILL CL - Lean Clay, brown (10yr 5/3), moist, low plasticity, 5% rock fragments.</p> <p>4.3 feet - end of boring. Refusal from firm sediment.</p>	
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10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 7B

Surface Elevation:

Exploration Equipment: Backsaver Date Logged: 17-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.7 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>TOPSOIL / PEAT? ML - Silt with high organic matter. black (10yr 2/1)</p> <hr/> <p>SAND LENS SM - Silty sand (fine grained sand), greenish gray (Gley 1 5/1GY) gleyed material, very moist, non plastic</p> <hr/> <p>ORGANIC RICH SILTY LAKE SEDIMENT ML - Silt with high organic matter. black (10yr 2/1), Moist, slightly to non plastic.</p> <hr/> <p>ORGANIC RICH SILTY LAKE SEDIMENT ML - Silt with high organic matter. black (10yr 2/1), very moist, slightly to non plastic.</p> <hr/> <p>3.7 feet - end of boring. Refusal from firm sediment.</p>	
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10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

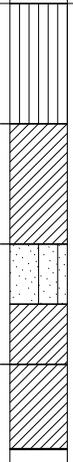
Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 8A

Surface Elevation: 1078.08

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 3.7 Coordinates(UTM): North - 1170614.131 East - 2208291.583

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>TOPSOIL ML - silt with high organic matter and lots of roots, very dark gray (10yr 3/1), slightly moist to moist, slightly to non plastic, friable, granular structure.</p>	
				<p>LAKE SEDIMENT CL - Lean clay, brown (10yr 4/3), slightly moist, low plasticity, firm.</p>	1080
				<p>SAND LENS SP-SM - Poorly graded sand with silt, light gray (10yr 7/2), slightly moist, non-plastic.</p>	
				<p>DARK GRAY ORGANIC RICH LAKE SEDIMENT CL - Lean clay, dark gray (10yr 4/1) mixed with peat, moist, low plasticity, soft to slightly firm.</p>	
				<p>LAKE SEDIMENT CL - Lean Clay with Sand, Gray (5y 5/1) with dark yellowish brown concentrations (10yr 3/6), Moist, low plasticity, soft to slightly firm.</p>	
				<p>3.7 feet - end of boring. Refusal from firm sediment.</p>	
5					
					1085
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. 9A

Surface Elevation: 1077.154

Exploration Equipment: Backsaver Date Logged: 18-Jul-2013

Logged By: T. Weisbrod Total Depth: 2.9 Coordinates(UTM): North - 1169543.854 East - 2208277.344

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				<p>TOPSOIL ML - Silt with organic matter and roots, very dark grayish brown (10yr 3/2), moist, slightly plastic, slightly firm.</p> <p>YELLOWISH BROWN GLACIAL TILL CL - Lean clay with sand and 5% rock fragments, yellowish brown (10yr 5/4), moist to slightly moist, low to medium plasticity, and slightly firm.</p> <p>2.9 feet - end of boring. Refusal from firm sediment.</p>	1080
5					
10					1085



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. BA 3

Surface Elevation:

Exploration Equipment: Bucket Auger Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 7.8 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				DARK BROWN GLACIAL TILL CL - Dark Brown (10yr3/2) Lean Clay with 5% rock fragments, moist, firm, low plasticity.	
		Sample 3A		PALE BROWN GLACIAL TILL (NOT MOTTLED) CL - Pale Brown (10yr6/3) Lean Clay, very moist, low plasticity.	
				LONG TERM WT CL - Yellowish Brown (10yr 5/6) Iron concentration in lean clay, very moist.	
5		Sample 3B		PALE BROWN GLACIAL TILL (MOTTLED) CL - Pale Brown (10yr 6/3) Lean Clay with sand and light gray (10yr 7/1) reduced areas and yellowish brown (10yr 5/6) concentrations. Low plasticity, very moist, soft, 5% gravel.	
				BROWN TILL CL - Brown (10yr 5/3) lean clay with sand. Low plasticity, very moist, soft, 5% gravel.	
		Sample 3C		GRAYISH BROWN TILL ML - Grayish Brown (10yr 5/2) lean clay with sand. slightly plastic, slightly moist to moist, soft, 5% gravel.	
				7.8 feet - end of boring. No refusal	
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. BA 4

Surface Elevation: 1074.008

Exploration Equipment: Bucket Auger Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 6.5 Coordinates(UTM): North - 1177150.735 East - 2208495.289

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				TOPSOIL ML - Grayish Brown (10yr 3/2) silt, dry.	
				SILTY GLACIAL LAKE SEDIMENT (NOT MOTTLED) ML - Light Brownish Gray (10yr 6/2) silt with sand, dry, non-plastic, friable, and soft when wet.	1075
				SILTY GLACIAL LAKE SEDIMENT (MOTTLED). ML - Light Brownish Gray (10yr 6/2) silt with sand and yellowish brown (10yr 5/8) concentrations, very most, soft to very soft and non-plastic.	
5		Sample 4			
				6.5 feet - end of boring. No refusal	1080
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. BA 5

Surface Elevation:

Exploration Equipment: Bucket Auger

Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 6.8 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				TOPSOIL CL - Very Dark Greyish Brown (10yr 3/2) Lean Clay.	
				CLAYEY GLACIAL LAKE SEDIMENT (MOTTLED) CL - Grayish Brown (10yr 5/2) lean clay with light gray (10 yr 7/1) reduced areas and very pale brown (10 yr 7/4) concentrations. Moist, friable and low plasticity.	
				CLAYEY GLACIAL LAKE SEDIMENT (MOTTLED) CL - Grayish Brown (10yr 5/2) Glacial Lake Sediment with light gray (10 yr 7/1) reduced areas and very pale brown (10 yr 7/4) concentrations. Moist, friable, and low plasticity.	
		Sample 5A		CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CH/ML - Dark Gray (10yr 4/1) fat clay low to medium plasticity (CH) layered with light brownish gray (10yr 6/2) non-plastic silt (ML) with Yellow (10 yr 3/6) concentrations at 4.0 ft. Moist, slightly firm.	
		Sample 5B		CLAYEY GLACIAL LAKE SEDIMENT CL - Dark Gray (10yr 4/1) Lean Clay, no distinct layering, firm, moist, low to medium plasticity.	
		Sample 5C		RESIDIUM / TILL? CL - Dark Greyish Brown (10yr 4/2) Lean Clay, moist, firm, low to med. plasticity, 5-10% weathered granite fragments.	
				7.8 FT - END OF BORING - HARD ROCK REFUSAL - GRANITE - BEDROCK OR COBBLE LAYER	



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. BA 6

Surface Elevation: 1069.615

Exploration Equipment: Bucket Auger

Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 7 Coordinates(UTM): North - 1177150.319 East - 2208454.56

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				TOPSOIL ML - Light Gray (10yr 3/2) silt, moist, friable, non plastic.	1070
				SILTY GLACIAL LAKE SEDIMENT (MOTTLED) ML - Pale Brown (10yr 6/3) silt with gray (10yr 6/1) reduced areas and pale brown concentrations. moist to very wet, soft, non-plastic.	
				SILTY GLACIAL LAKE SEDIMENT (GLEYPED) ML - Gleyed (Gley 1 - 4N) silt with sand, non-plastic, very moist, soft to very soft.	
		Sample 6A			
				CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CH/ML - Black (10yr 2/1) low to medium plasticity fat clay (CH) layered with gray (10yr 6/1) non plastic silt (ML). Moist, slightly firm, .	1075
		Sample 6B			
				CLAYEY GLACIAL LAEK SEDIMENT CH - Black (10yr 2/1) fat clay, medium plasticity, moist, very firm. A few layers of silt present.	
				7.0 FT - END OF BORING - NO REFUSAL	



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. BA 7

Surface Elevation:

Exploration Equipment: Bucket Auger

Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 9.8 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				TOPSOIL ML - light gray (10yr 3/2) silt with organic material	
				SANDY GLACIAL LAKE SEDIMENT (MOTTLED) SM - pale brown (10yr 6/3) silty sand with brownish yellow (10yr 6/6) concentrations. slightly moist, very soft, non-plastic.	
				CLAYEY GLACIAL LAKE SEDIMENT (MOTTLED) CL - dark grayish brown (10yr 4/2) lean clay with dark yellowish brown (10 yr 3/6) concentrations. low plasticity, moist.	
		Sample 7A		SANDY GLACIAL LAKE SEDIMENT (MOTTLED) SM - pale brown (10yr 6/3) silty sand with brownish yellow (10yr 6/8) concentrations. dry, dense, non-plastic, soft when wet.	
				SILTY GLACIAL LAKE SEDIMENT (MOTTLED) ML w/sand- pale brown (10yr 6/3) silty sand with brownish yellow (10yr 6/8) concentrations. dry, dense, non-plastic, soft when wet.	
		Sample 7B		SILTY GLACIAL LAKE SEDIMENT (GLEIED) ML w/sand - light greenish gray (gley 1 - 10/7y) silt with sand. moist, non-plastic, soft to very soft.	
10				9.8 FT - END OF BORING - NO REFUSAL	



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. BA 8

Surface Elevation:

Exploration Equipment: Bucket Auger Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 7 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
				TOPSOIL ML - light gray (10yr 3/2) silt with organic material	
				SILTY GLACIAL LAKE SEDIMENT (MOTTLED) ML w/sand - pale brown (10yr 6/3) silty sand with brownish yellow (10yr 6/6) concentrations. slightly moist, very soft, non-plastic.	
				SILTY GLACIAL LAKE SEDIMENT (GLEIED) ML w/sand - light greenish gray (gley 1 - 10/7y) silt with sand. moist, non-plastic, soft to very soft.	
5		8A		SILTY GLACIAL LAKE SEDIMENT (GLEIED) ML w/sand - light greenish gray (gley 1 - 10/7y) silt with sand. very moist, slightly plastic, soft to very soft.	
				SILTY GLACIAL LAKE SEDIMENT (GLEIED) ML - light greenish gray (gley 1 - 10/7y) silt. very moist, slightly plastic, soft to very soft.	
		8B		CLAYEY-SILTY GLACIAL LAKE SEDIMENT (VARVED) CH/ML - Black (10yr 2/1) low to medium plasticity fat clay (CH) layered with gray (10yr 6/1) non plastic silt (ML). Moist, slightly firm.	
				7.7 FT - END OF BORING - NO REFUSAL	
10					



Natural Resources Conservation Service

* Soil Classification in Accordance with ASTM D2488 - 93

Project: Bostic / Zippel County Road 4 Ditch Stabilization.
 Client: Lake of the Woods SWCD
 Location:

HOLE No. TP 1

Surface Elevation:

Exploration Equipment: Shovel Date Logged: 20-Nov-2013

Logged By: T. Weisbrod Total Depth: 2.5 Coordinates(UTM): North - East -

Depth (ft)	Graphic Log	Sample No.	Sample Type	MATERIAL DESCRIPTION	Elevation (ft)
	[Hatched Box]			TOPSOIL CL - Black (10yr 2/1) Lean Clay, moist, friable, low plasticity.	
		Sample 1		DARK GRAY TILL CL - Dark Gray (10yr 3/2) Lean Clay, moist, low plasticity, <5% rock fragments.	
				2.5 feet - end of boring. No refusal	
5					
10					

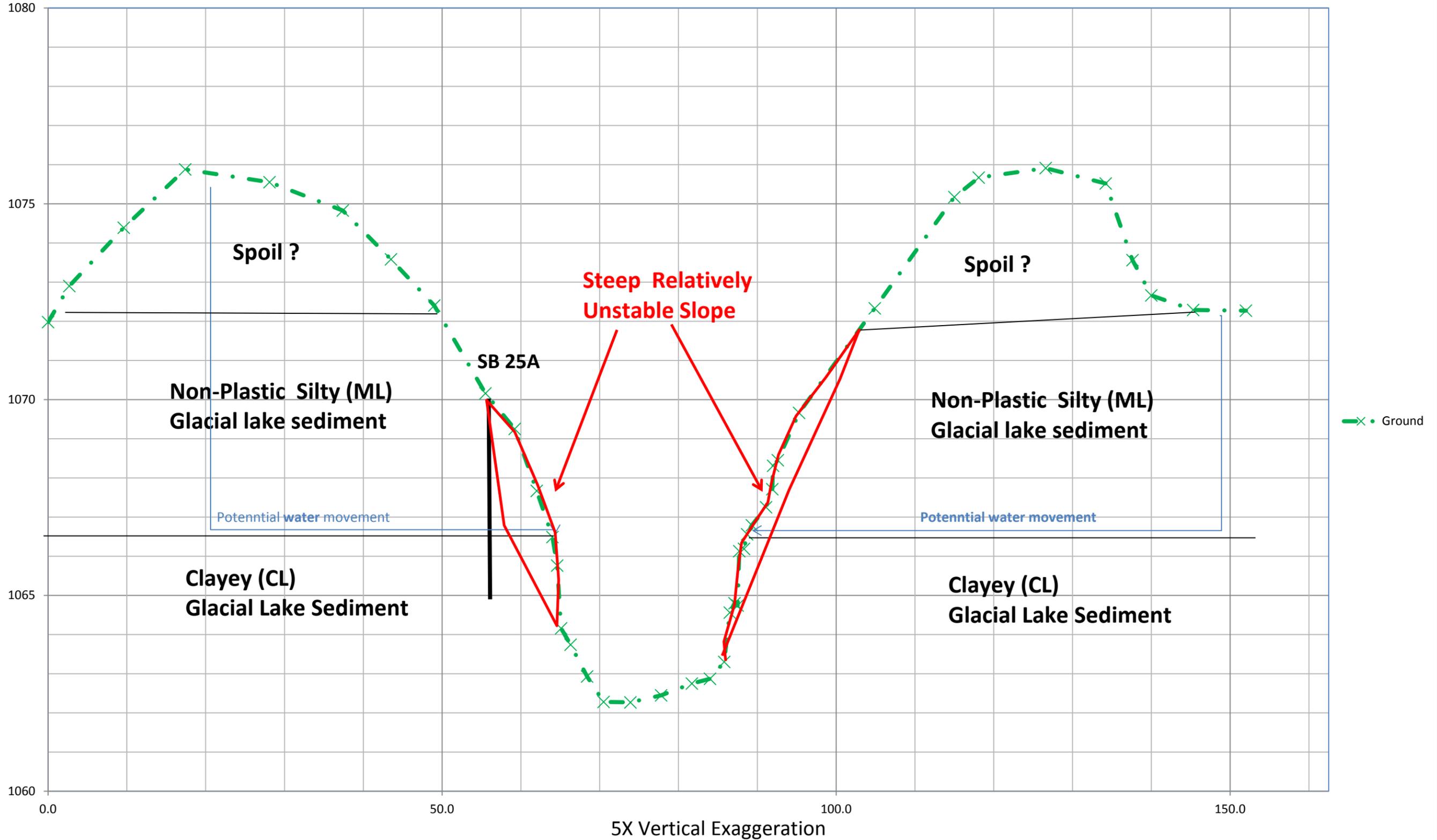


Natural Resources Conservation Service

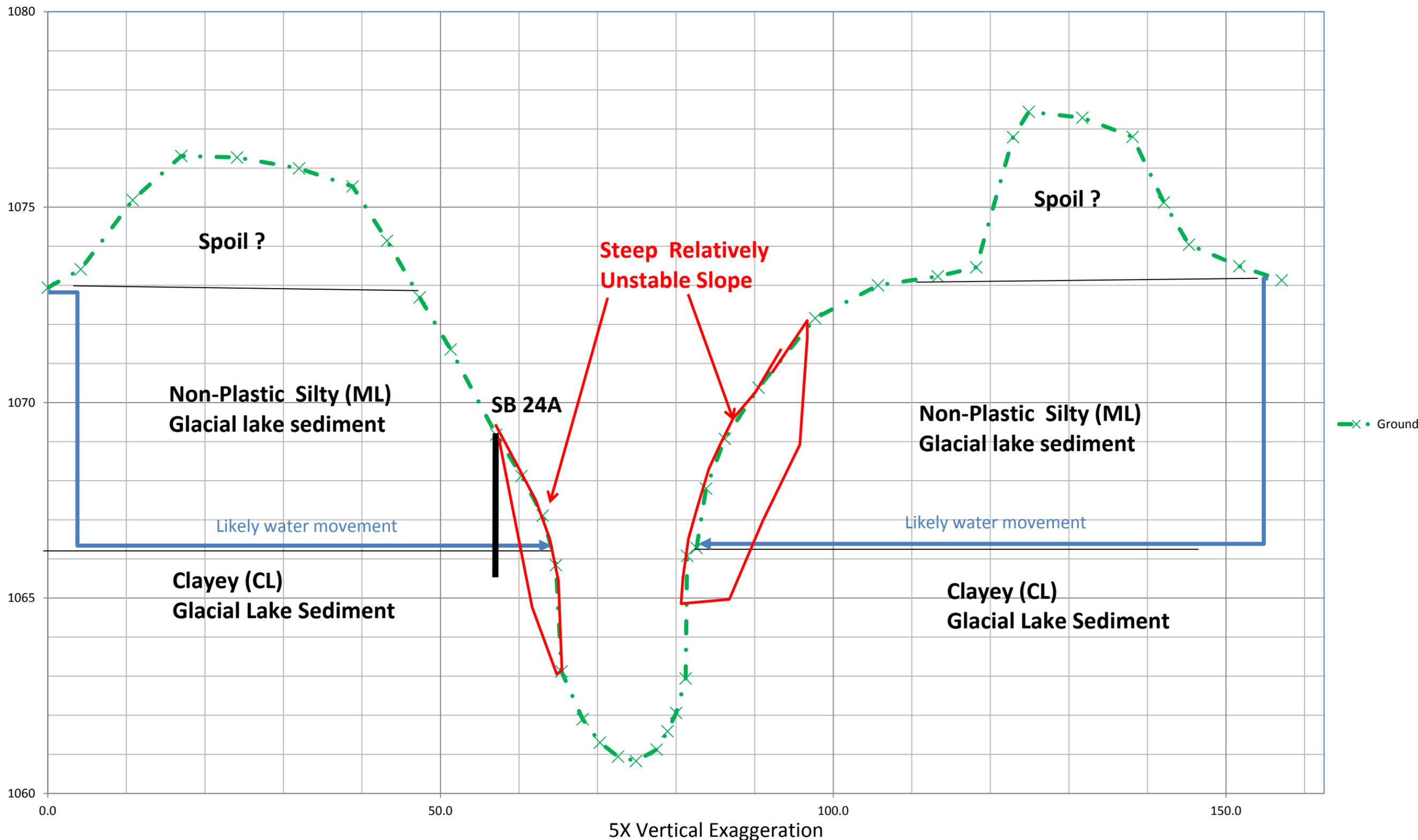
* Soil Classification in Accordance with ASTM D2488 - 93

Appendix C – Geologic Cross Sections

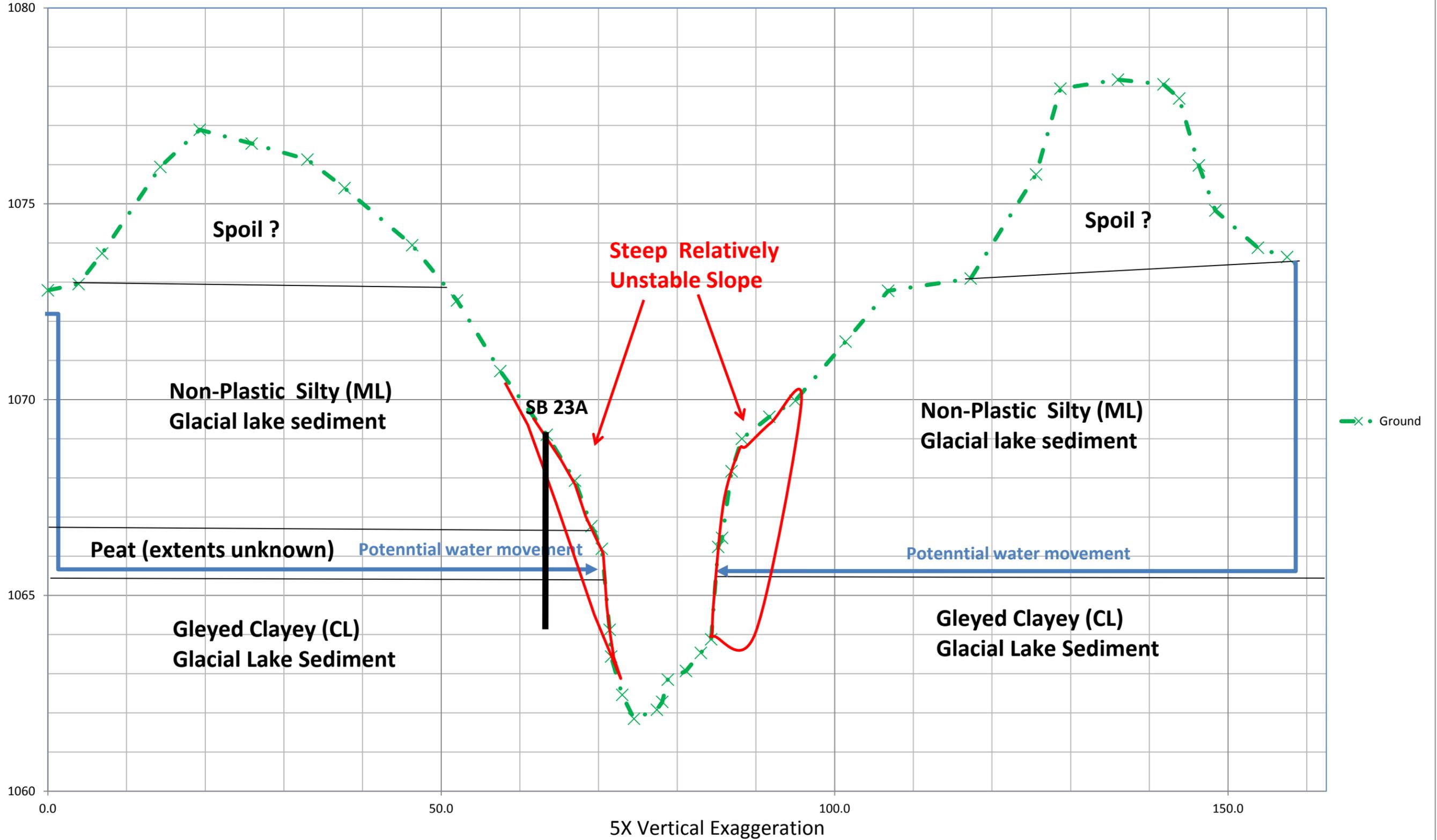
Cross Section at station 1193(ft)



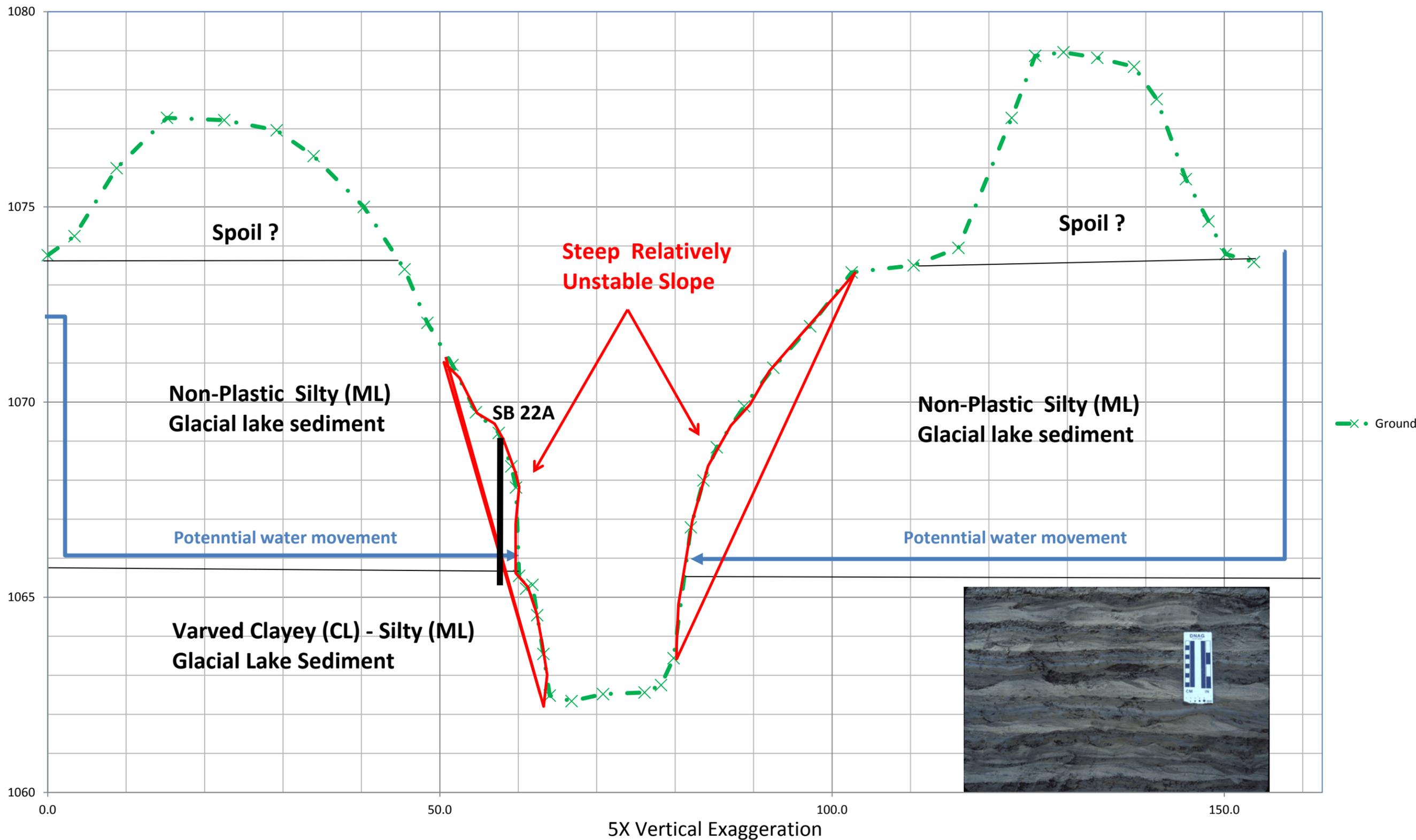
Cross Section at station 1447(ft)



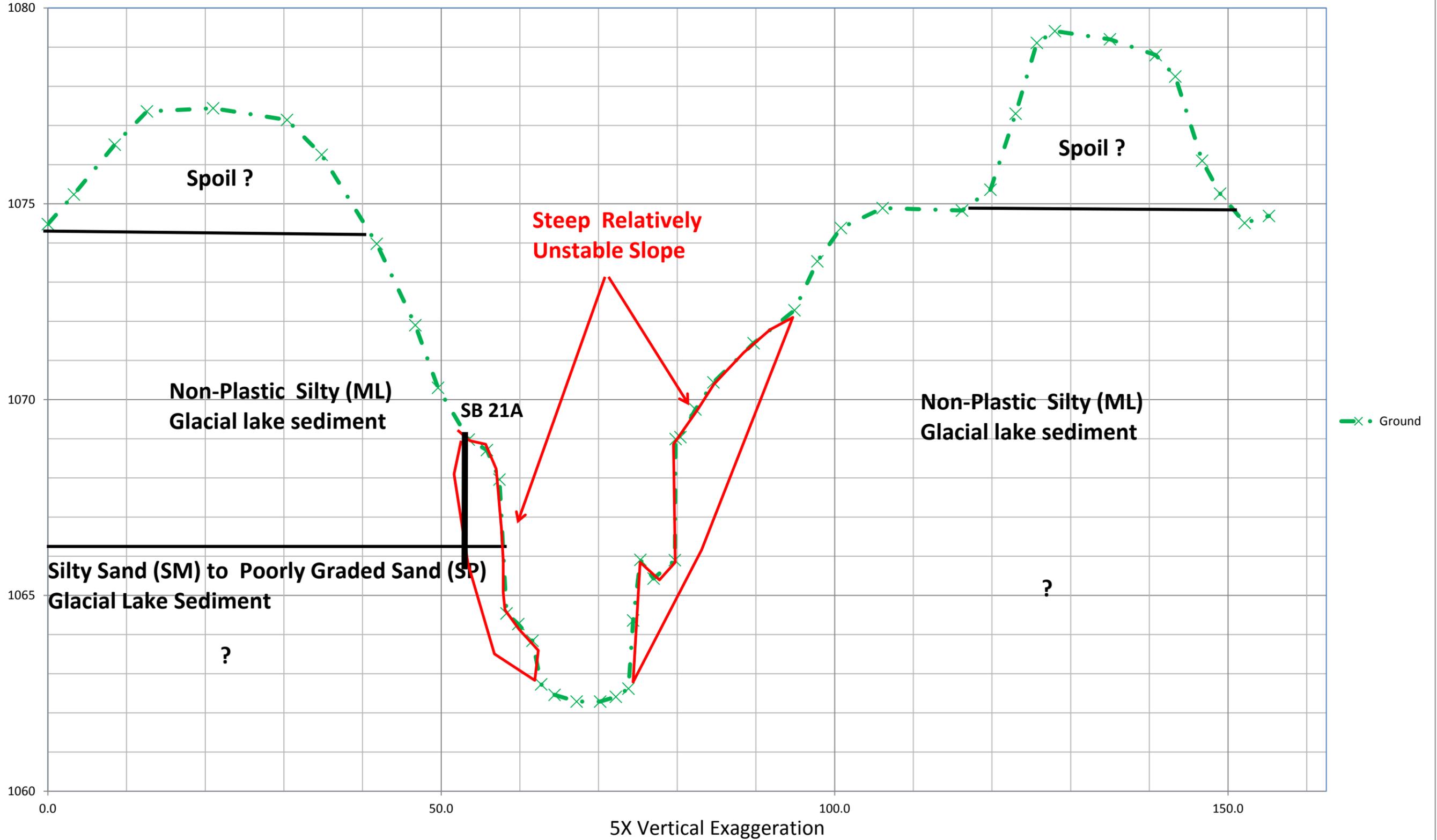
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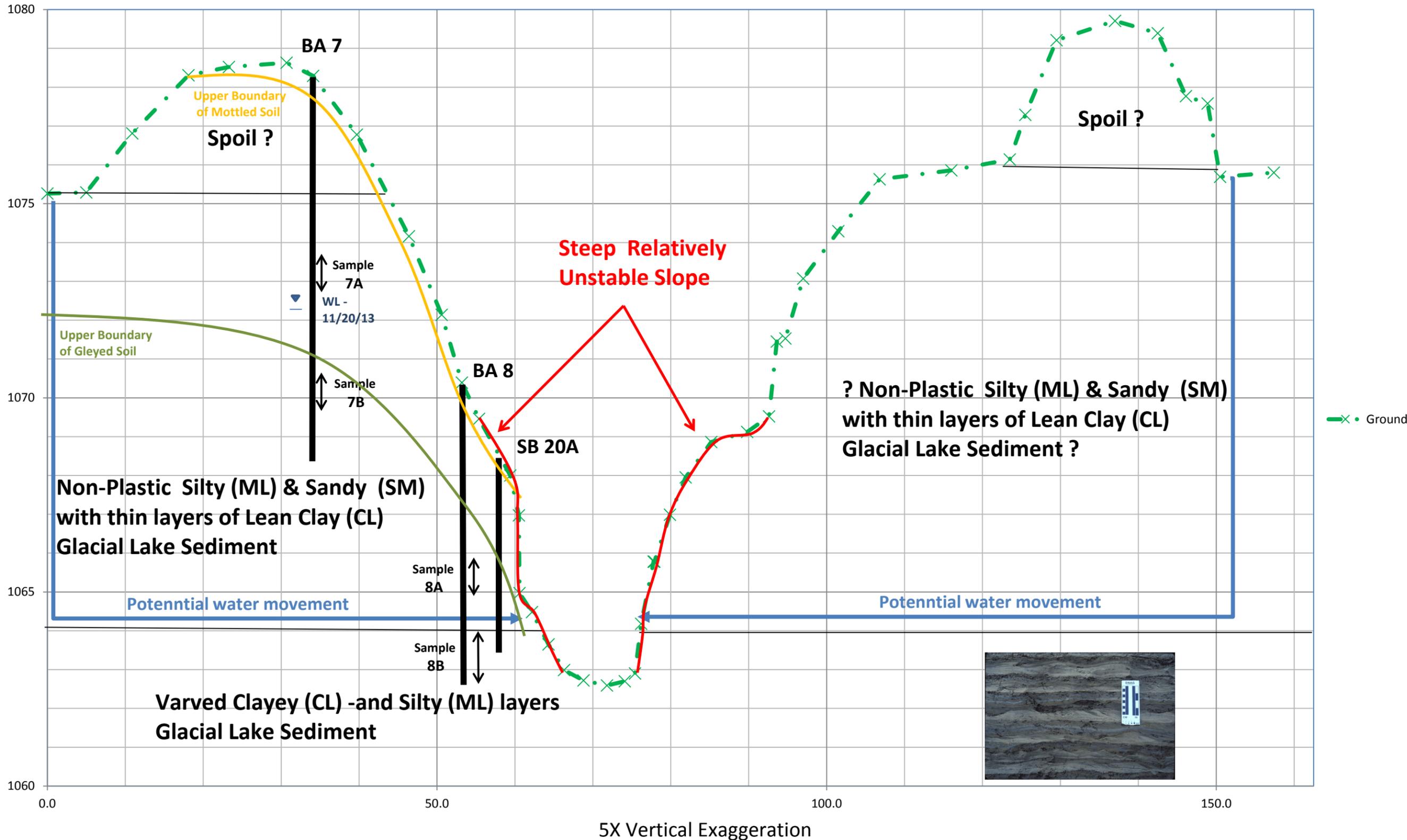
Cross Section at station 1968 (ft)



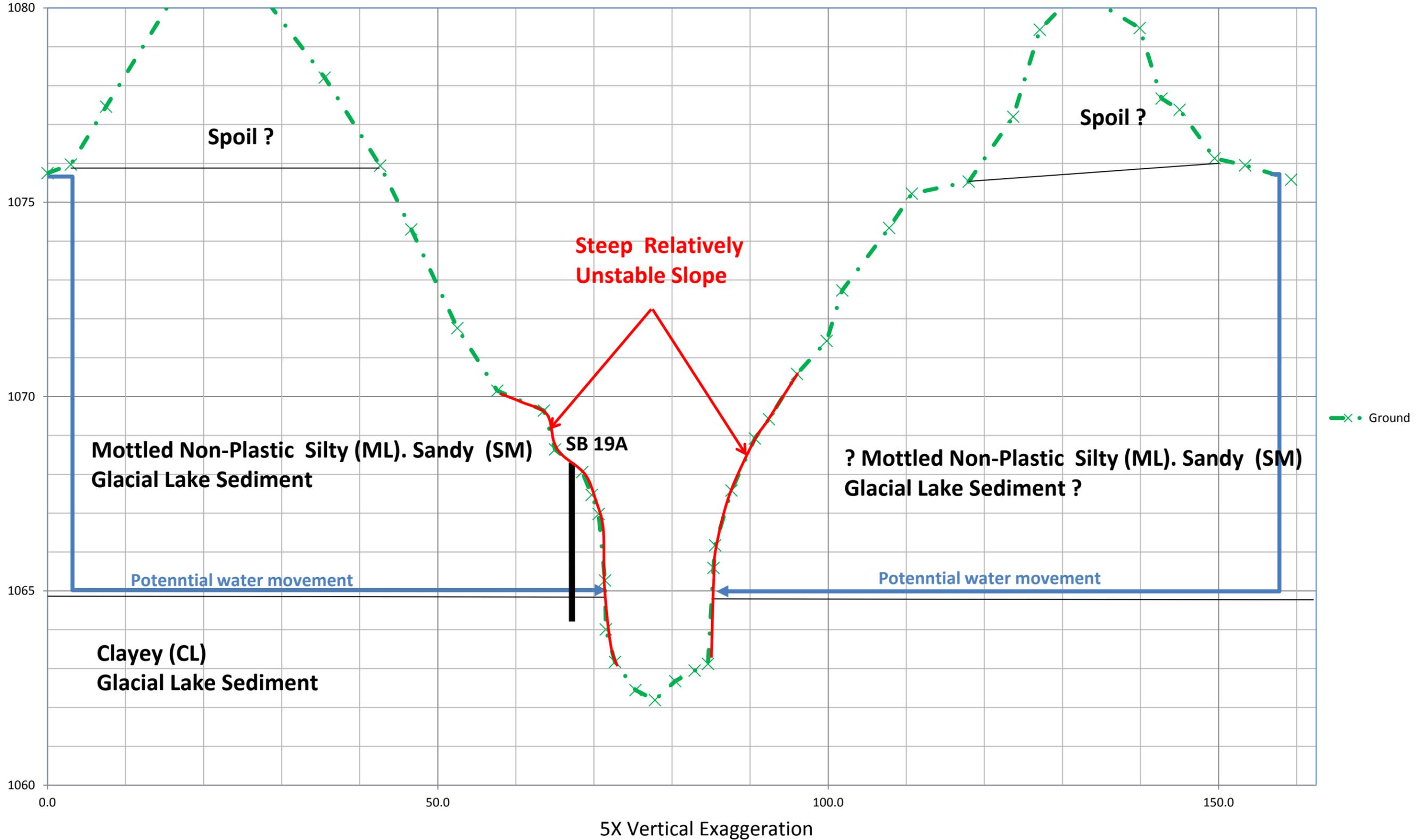
Cross Section at station 2226 (ft)



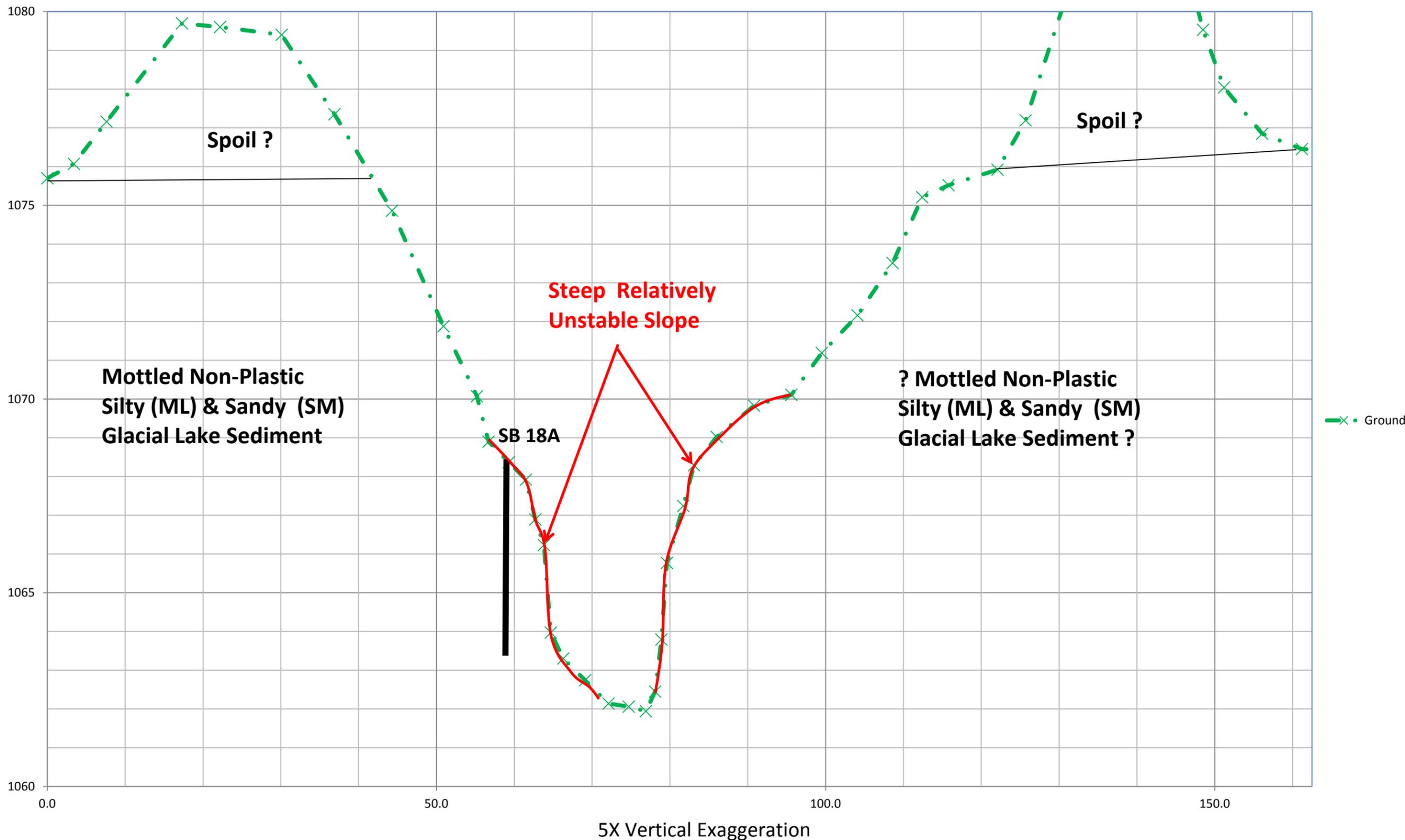
Cross Section at station 2488 (ft)



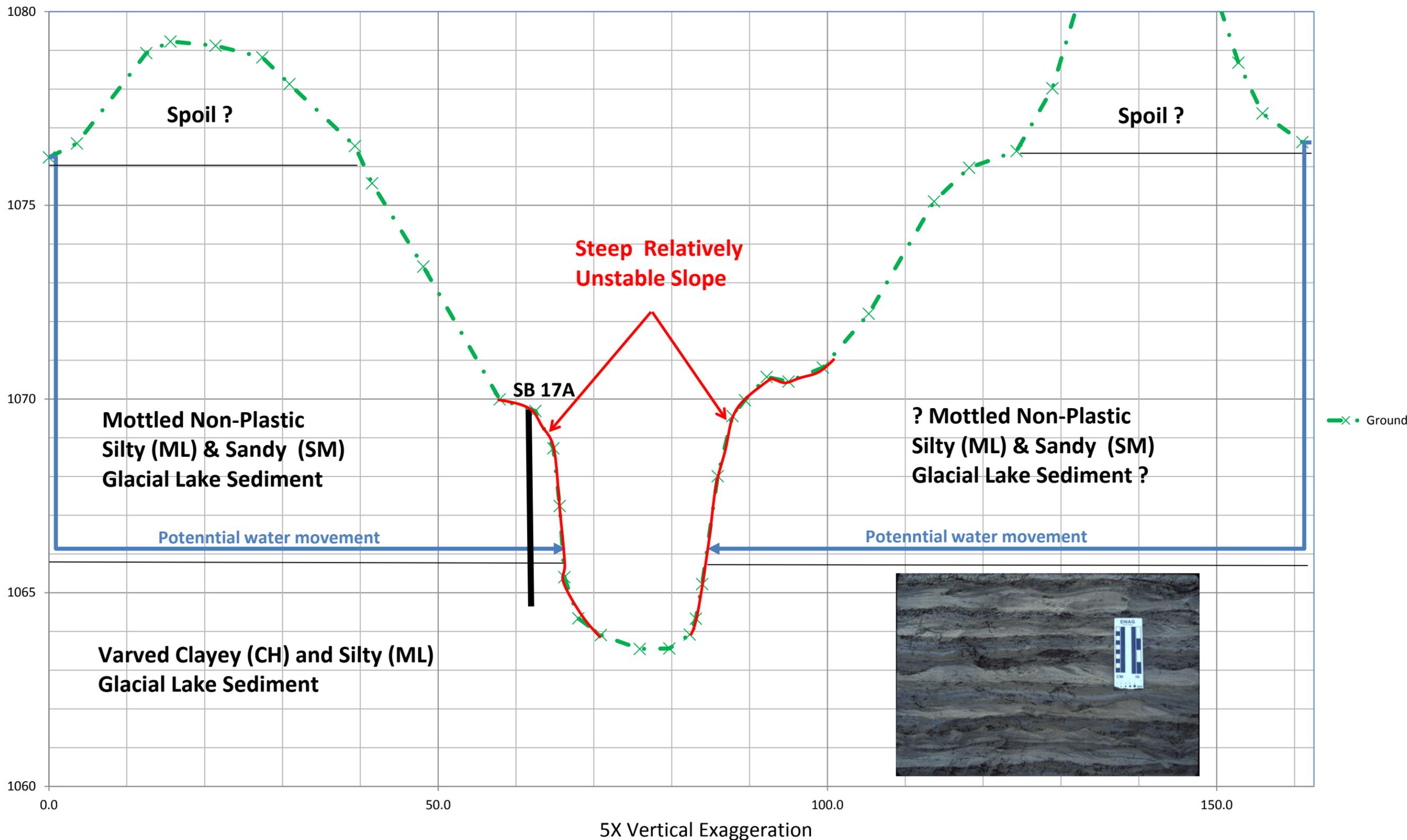
Cross Section at station 2753 (ft)



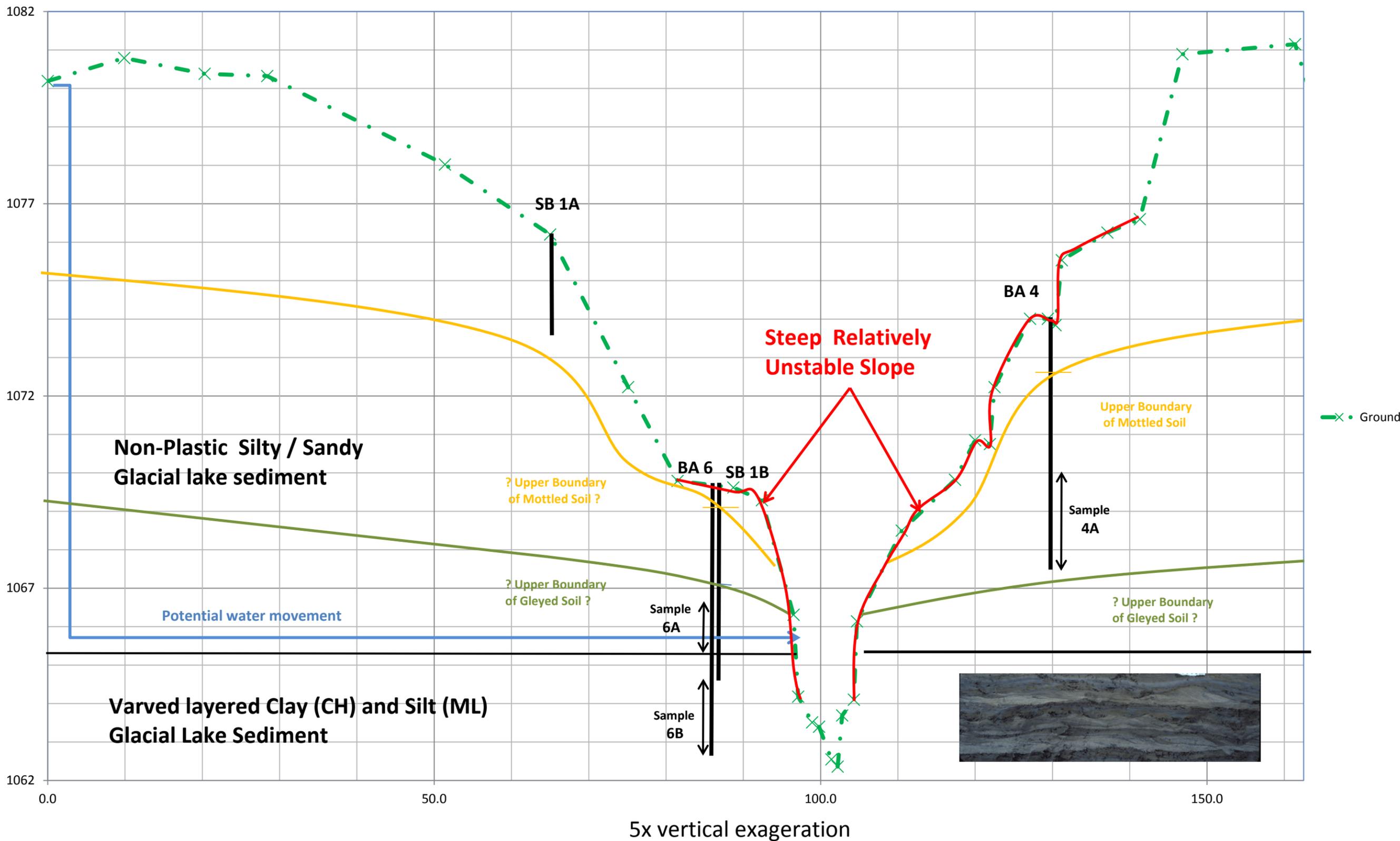
Cross Section at station 3015 (ft)



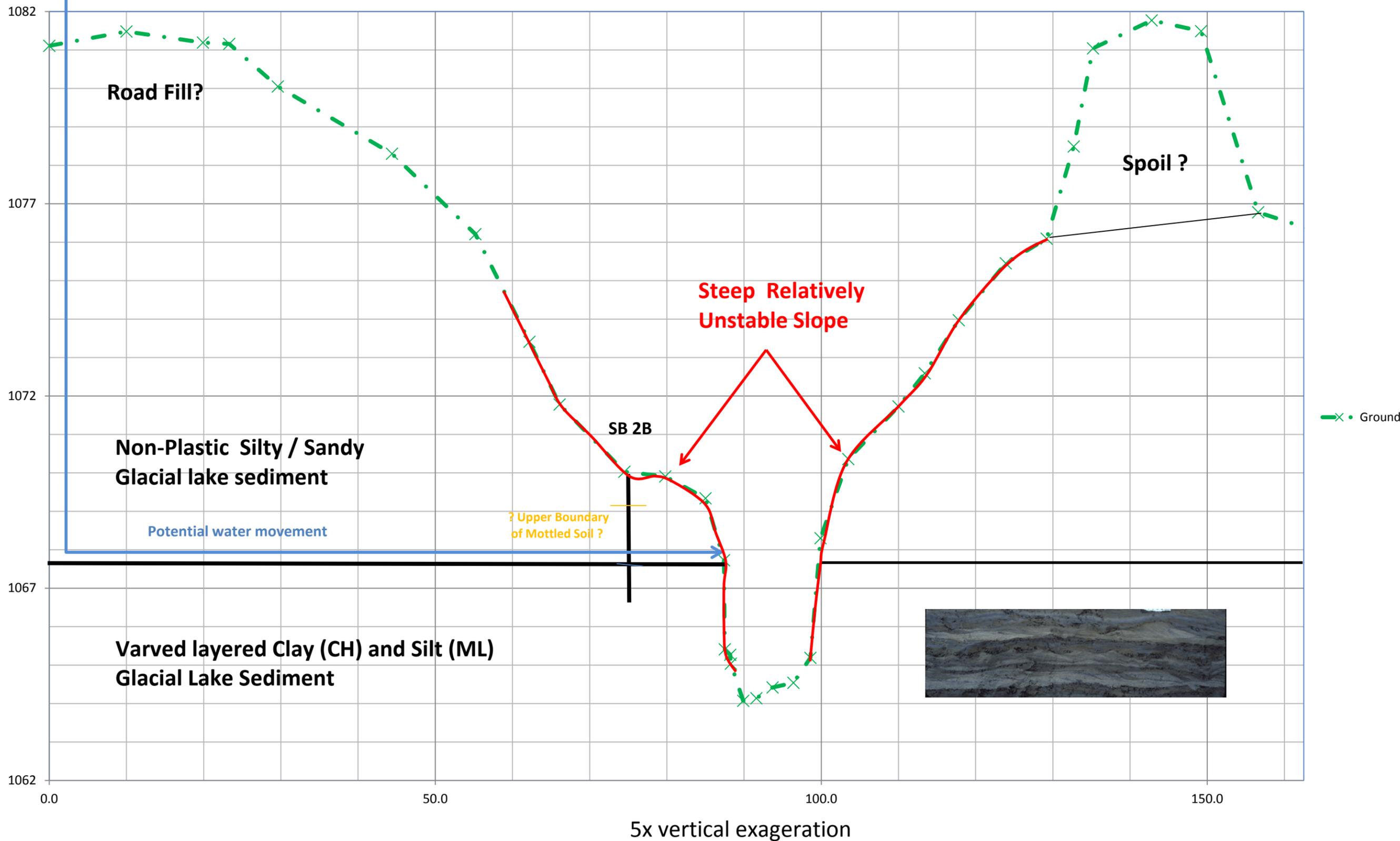
Cross Section at station 3275 (ft)



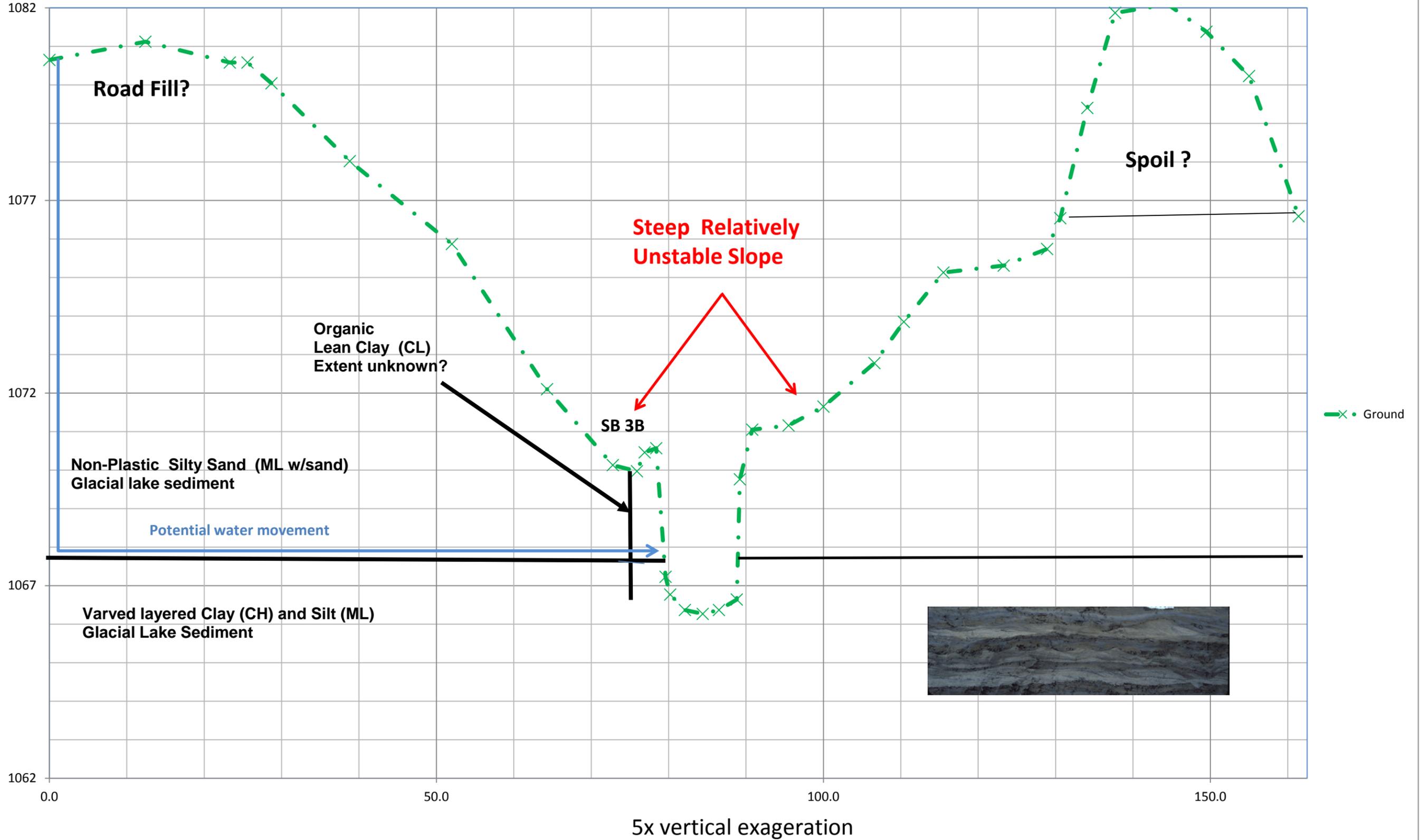
Cross Section at station 3821(ft)



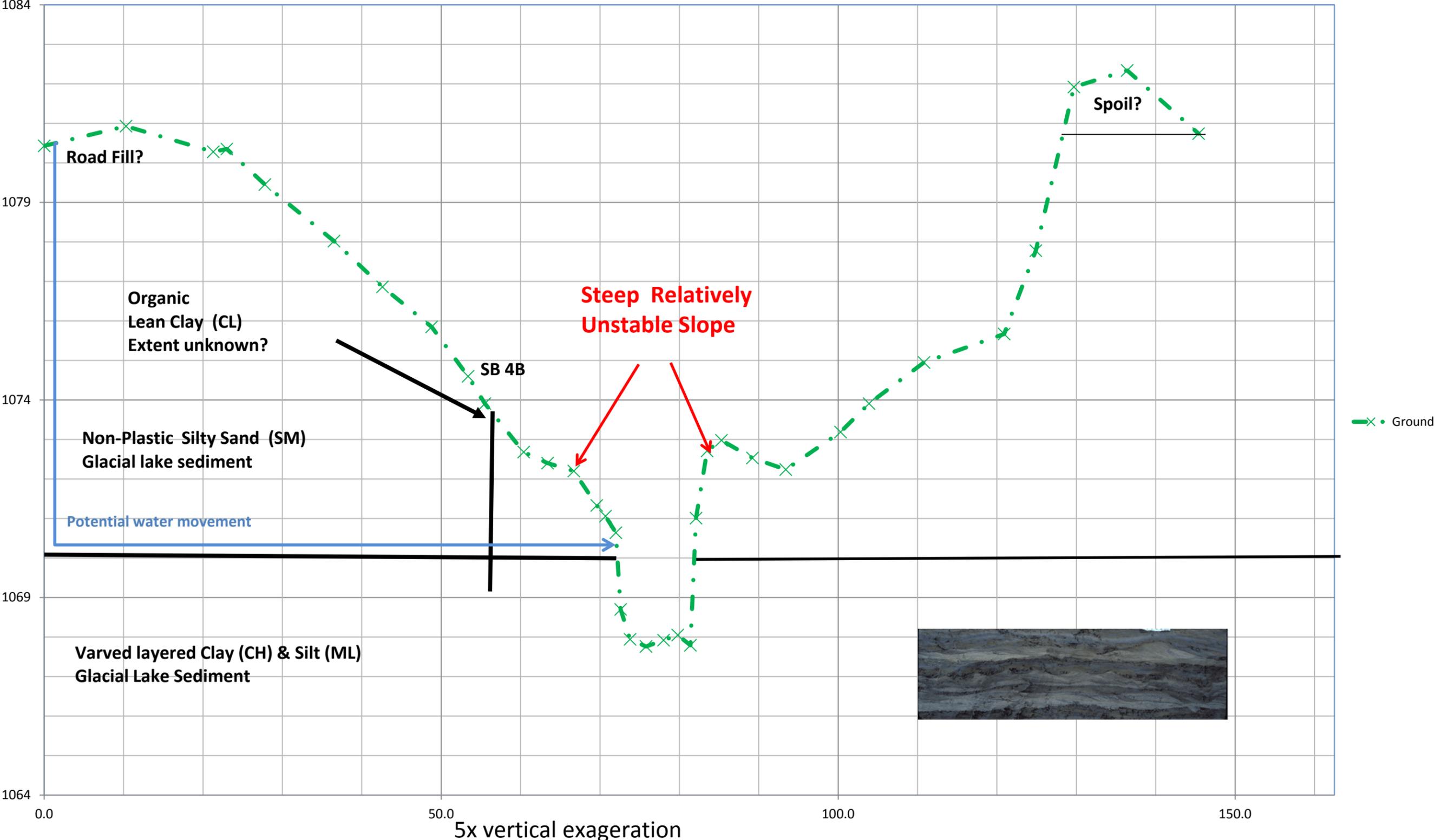
Cross Section at station 4326 feet



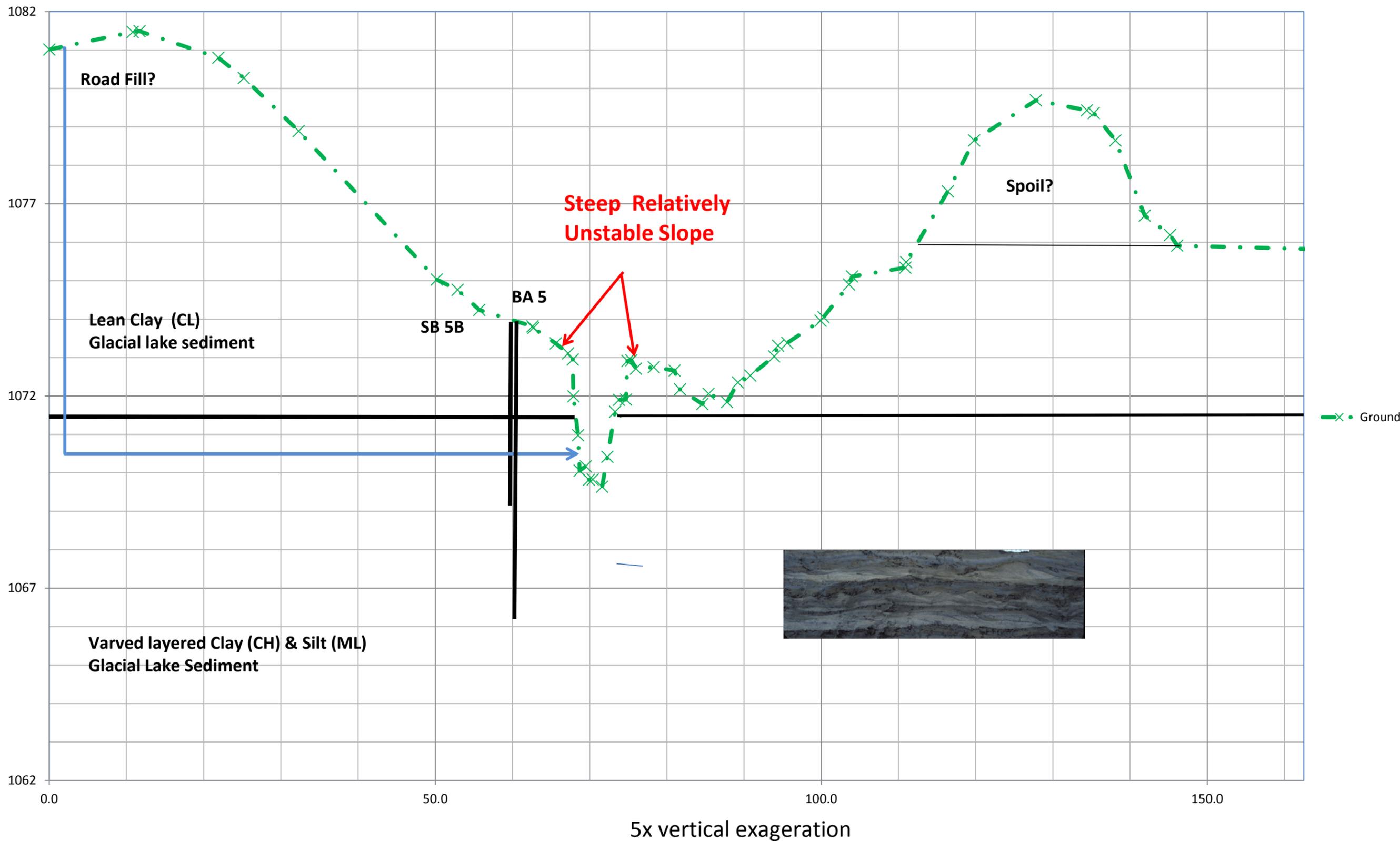
Cross Section at station 5645 feet



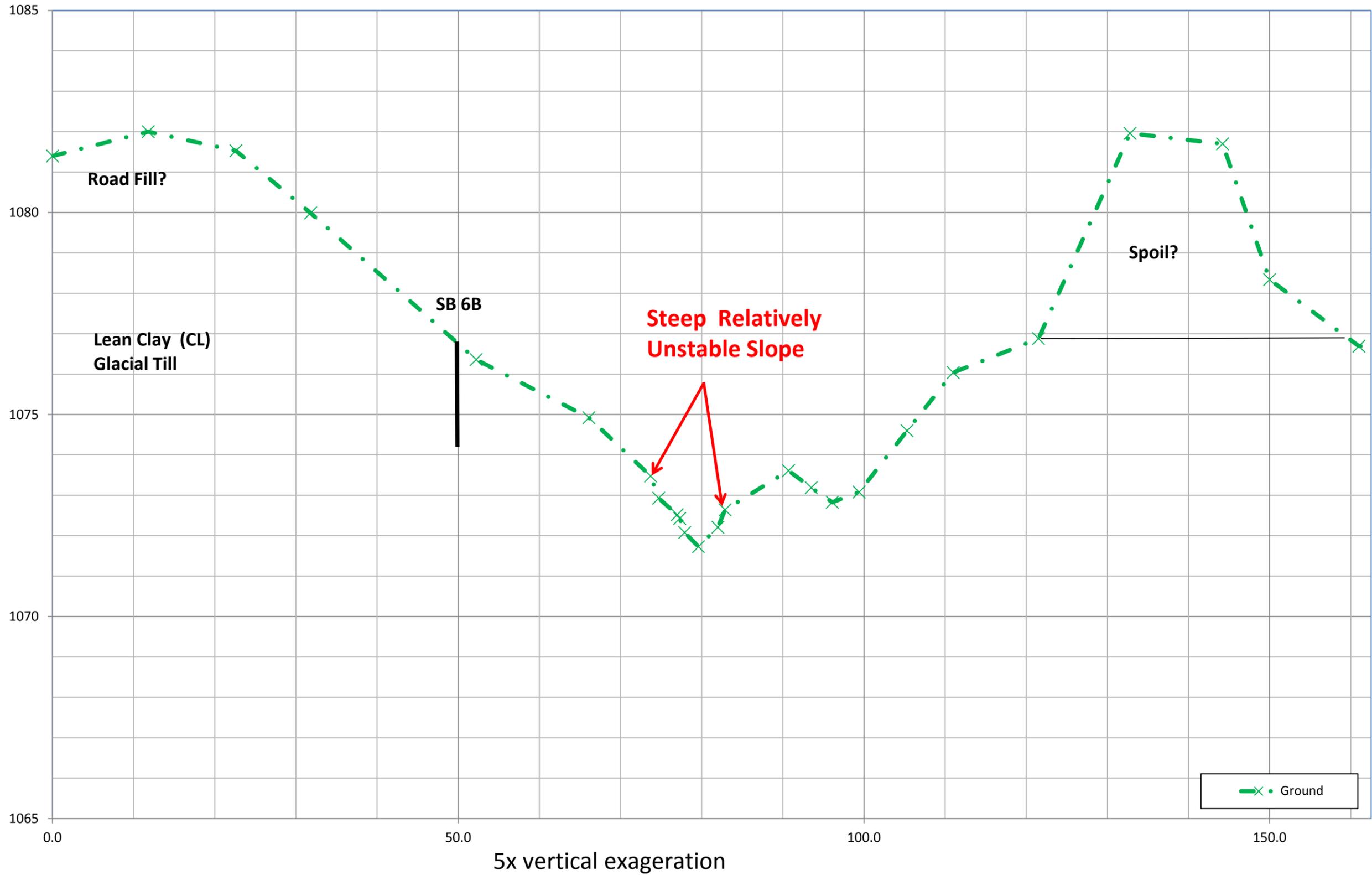
Cross Section at station 7274 feet



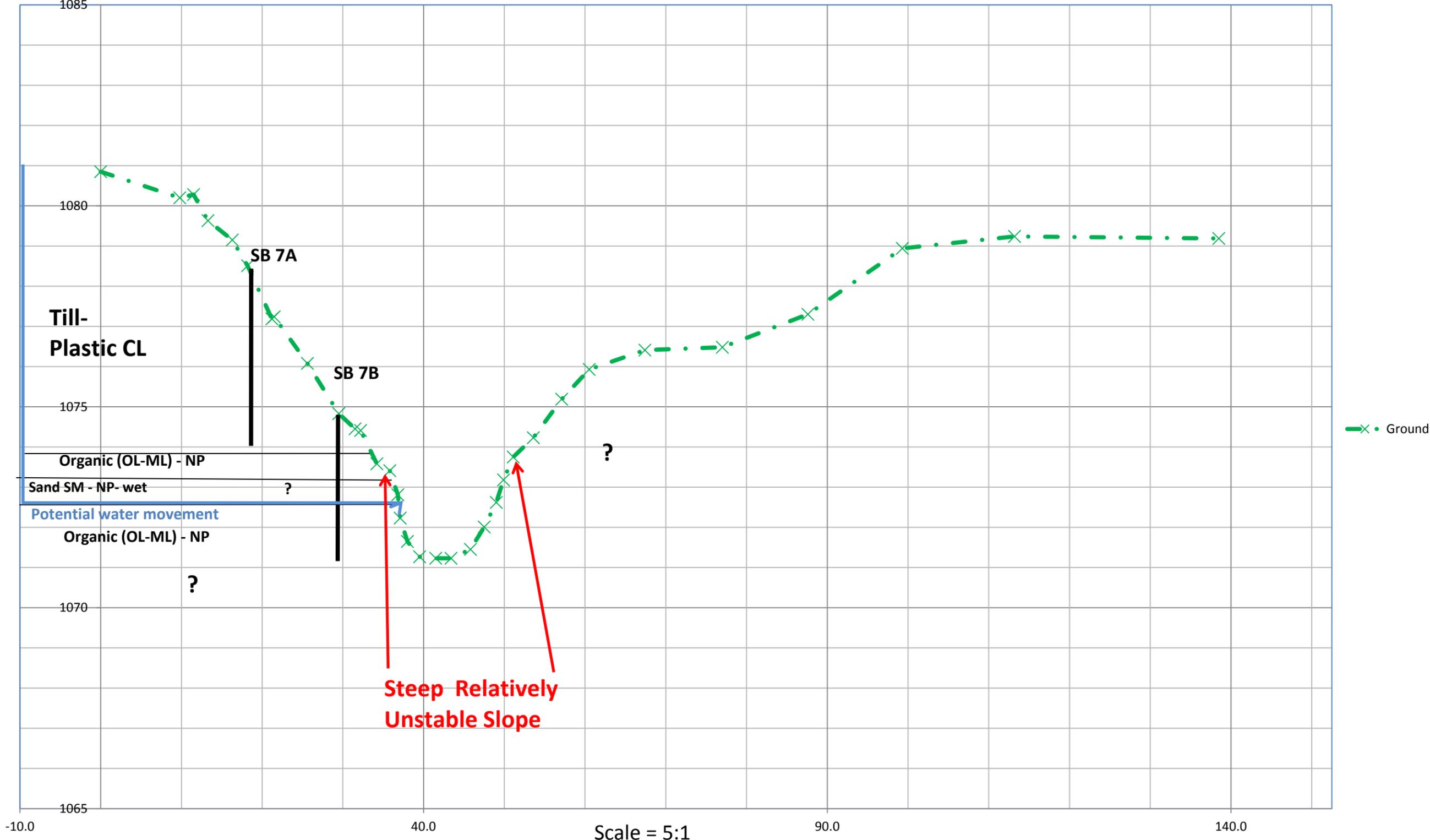
Cross Section at station 7992 feet



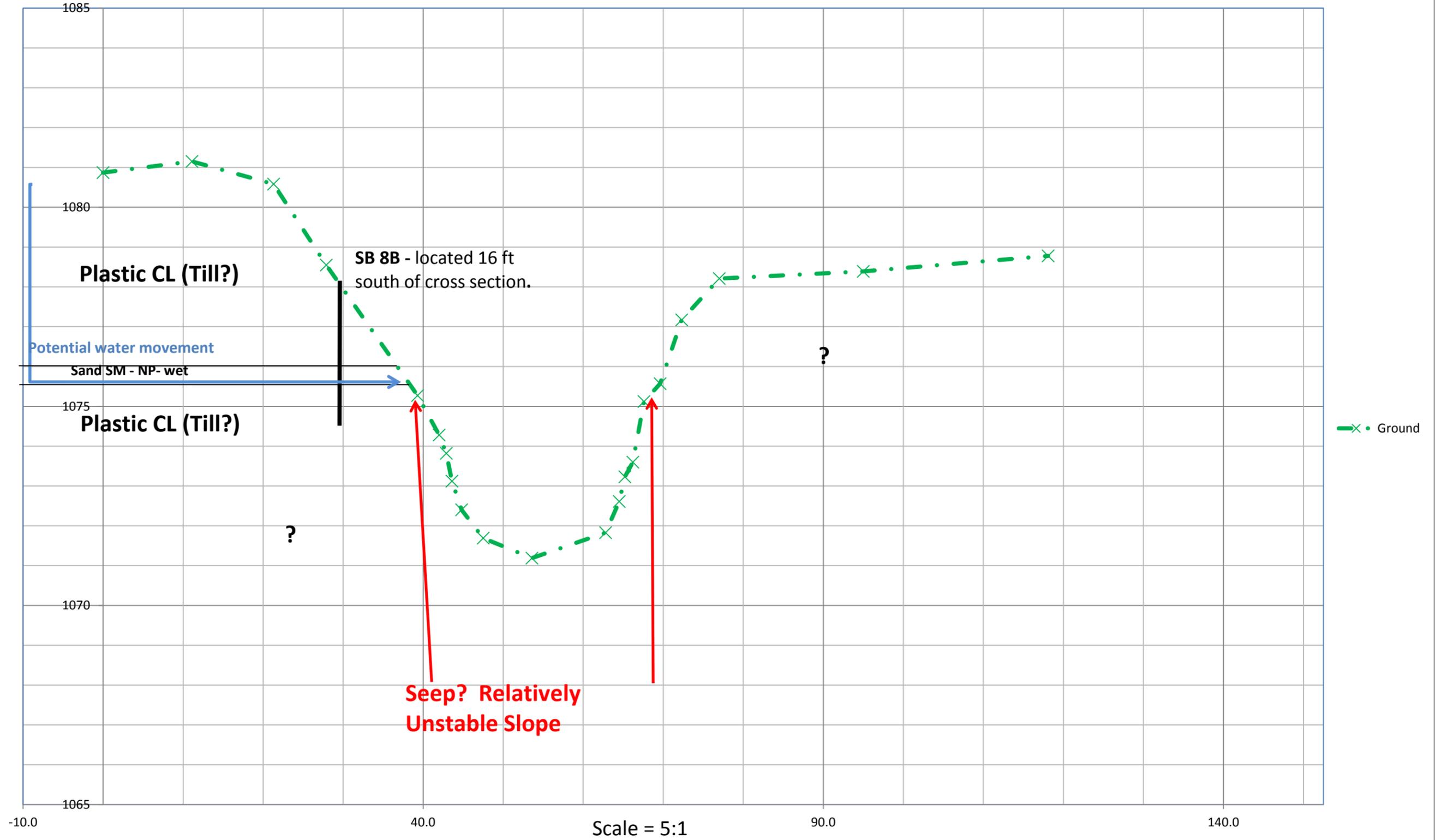
Cross Section at station 8715 feet



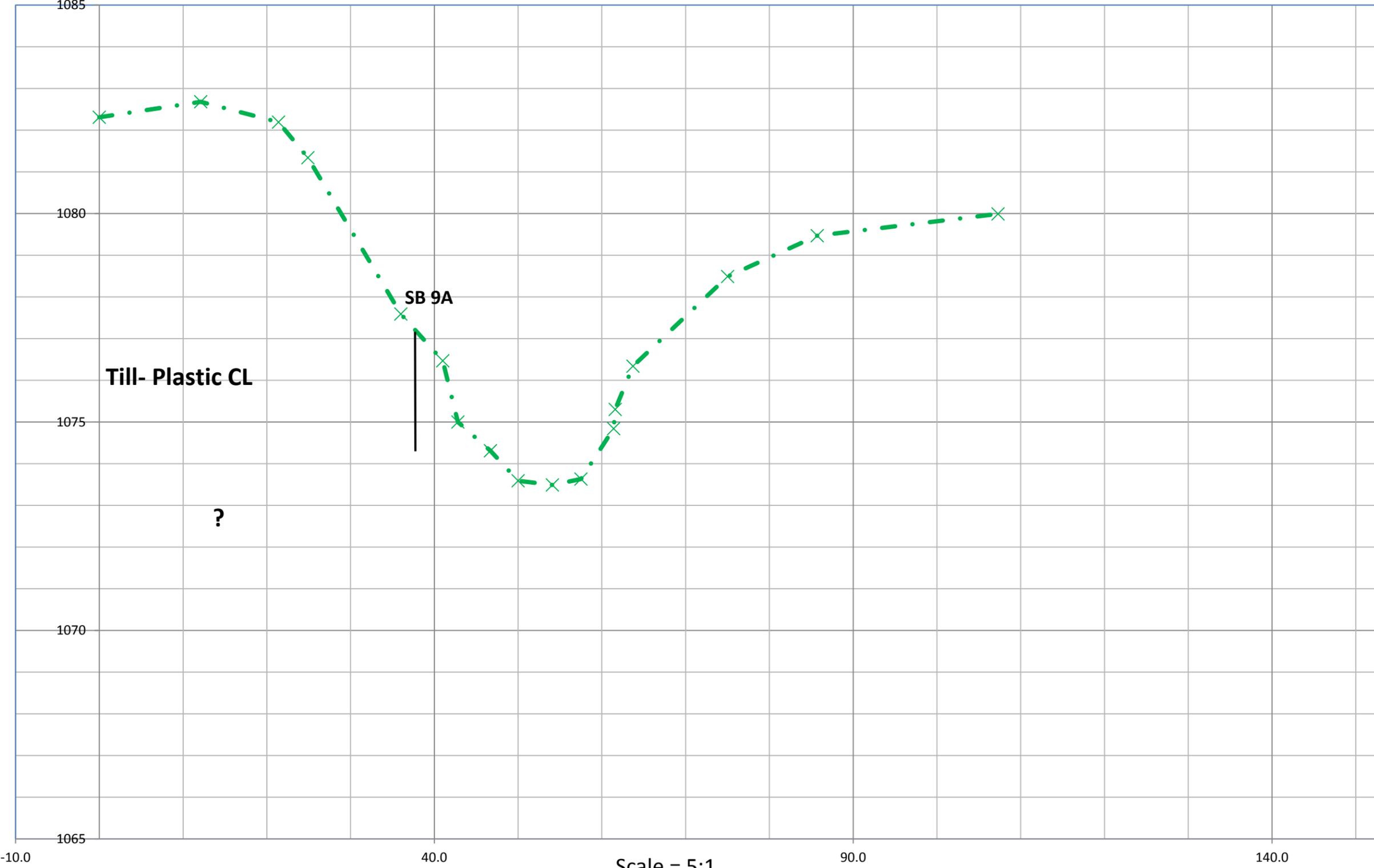
Cross Section at station 9904.7ft)



Cross Section at Station 10353 ft



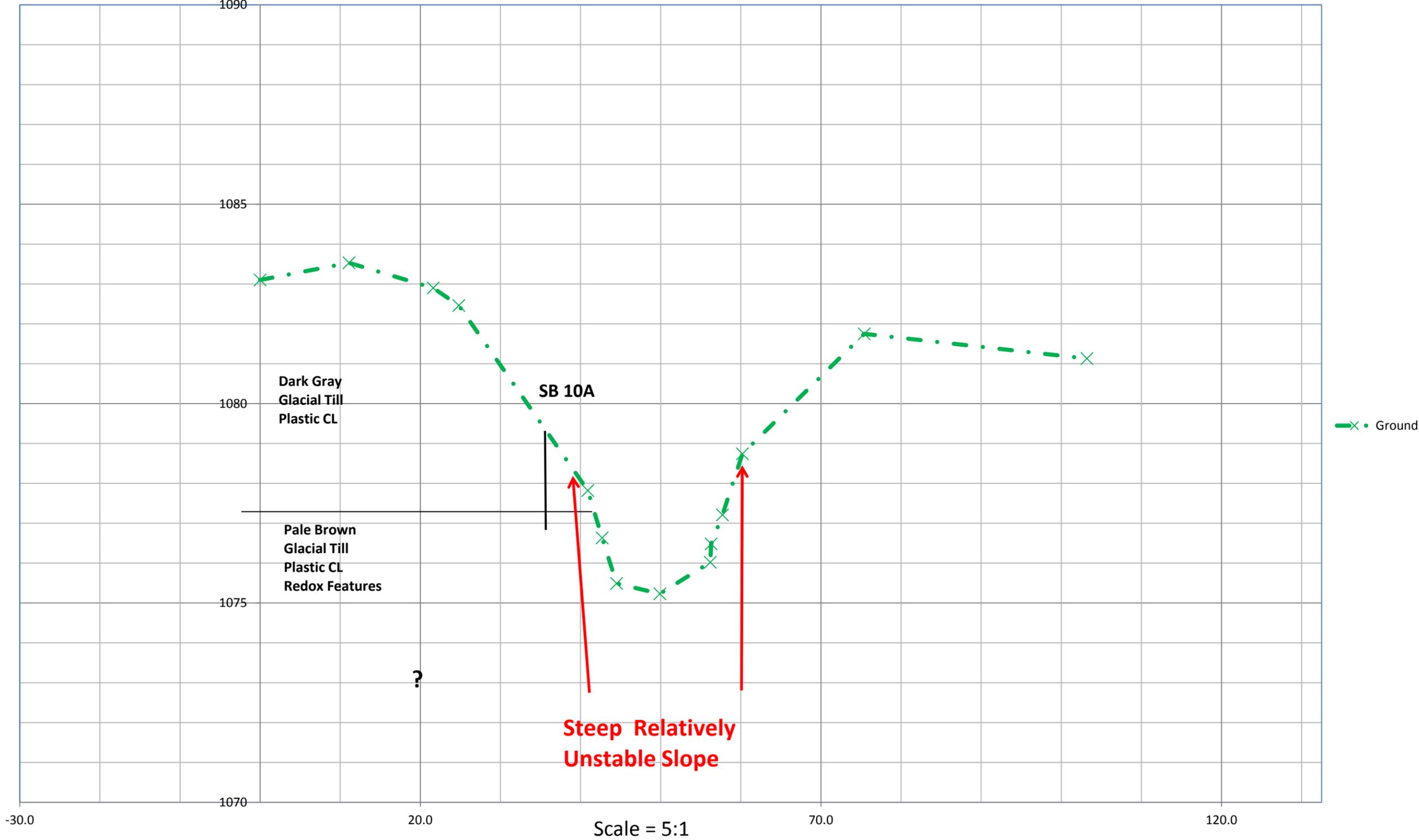
Cross Section at station 11440 ft)



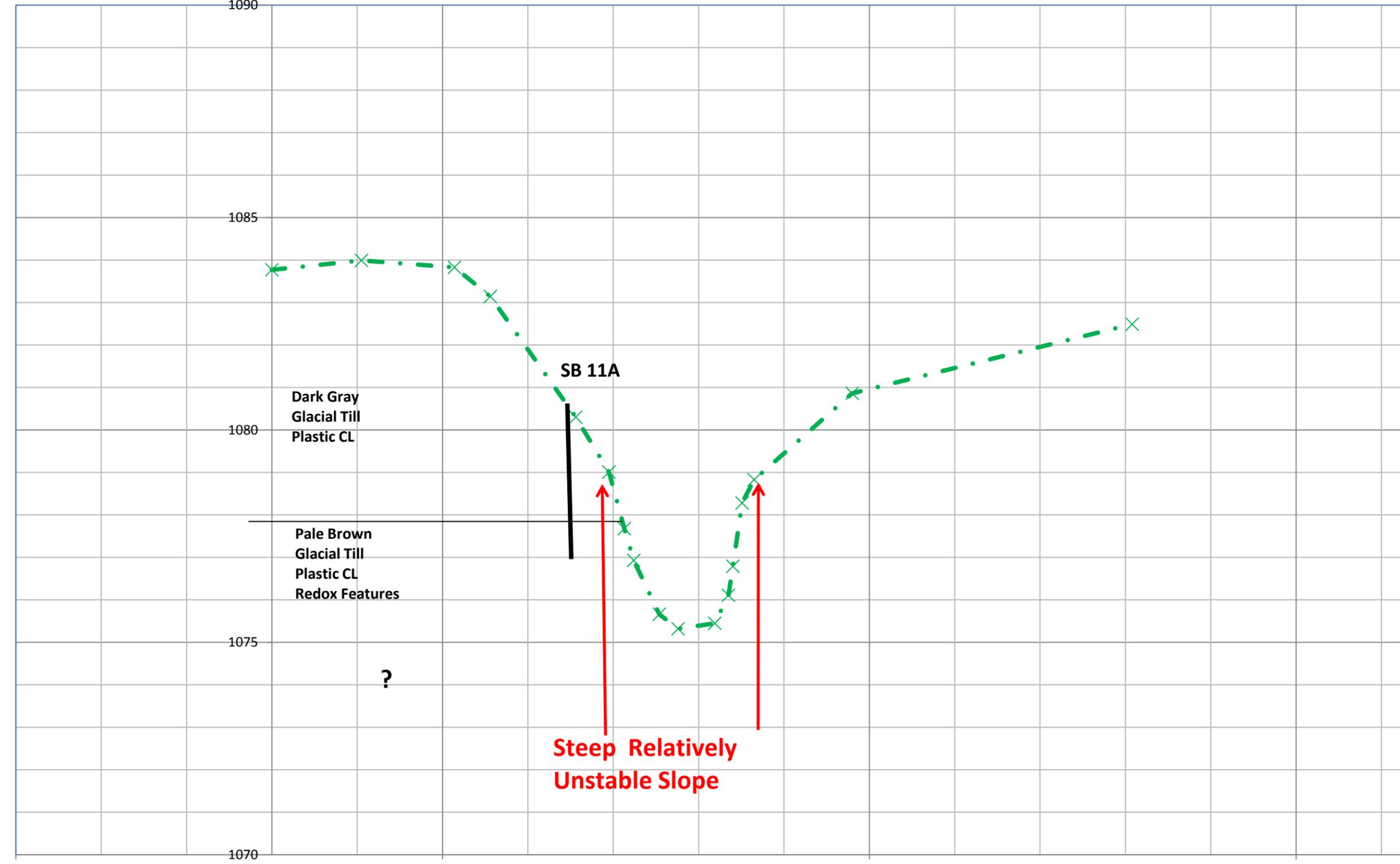
x • Ground

Scale = 5:1

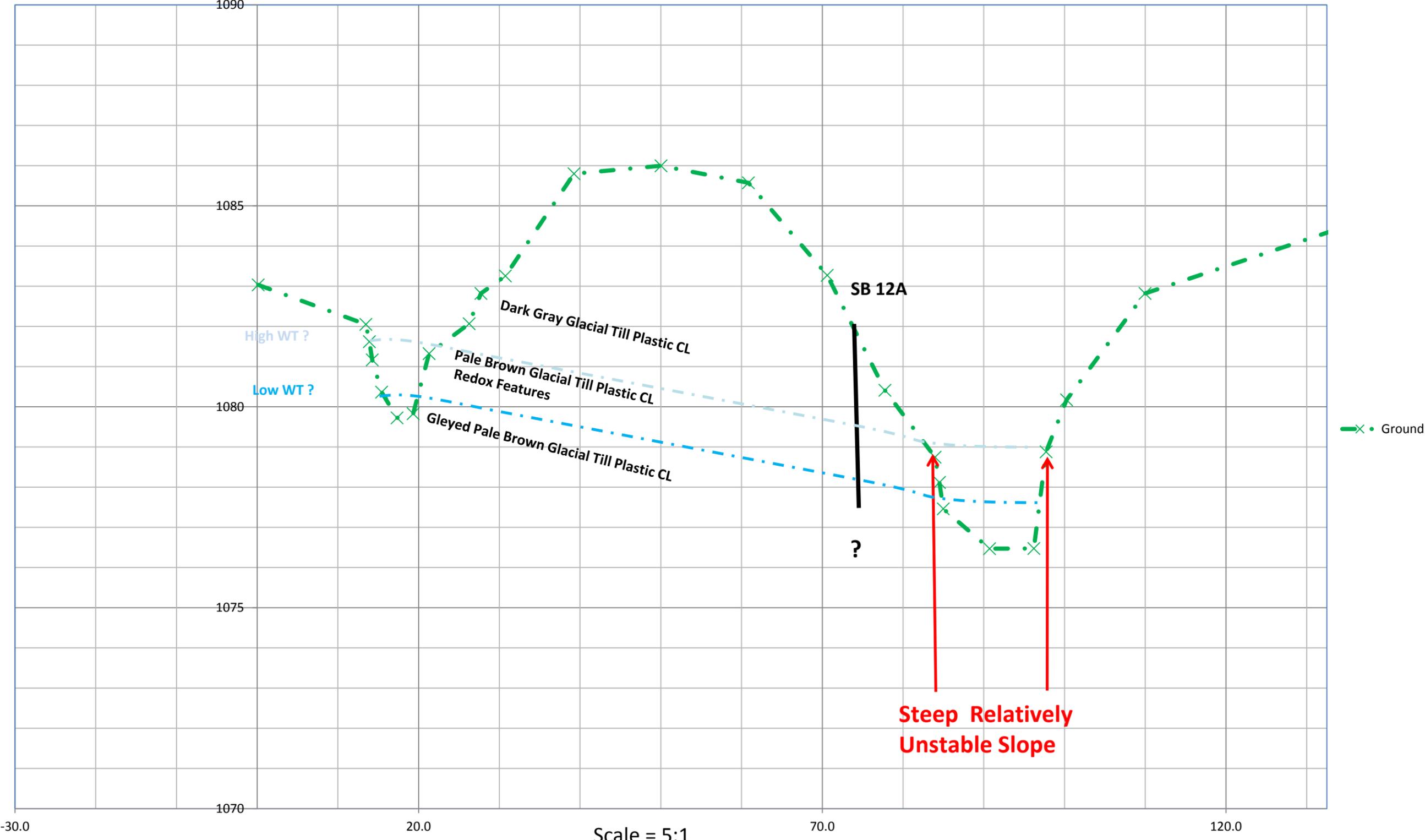
Cross Section at station 12878 (ft)



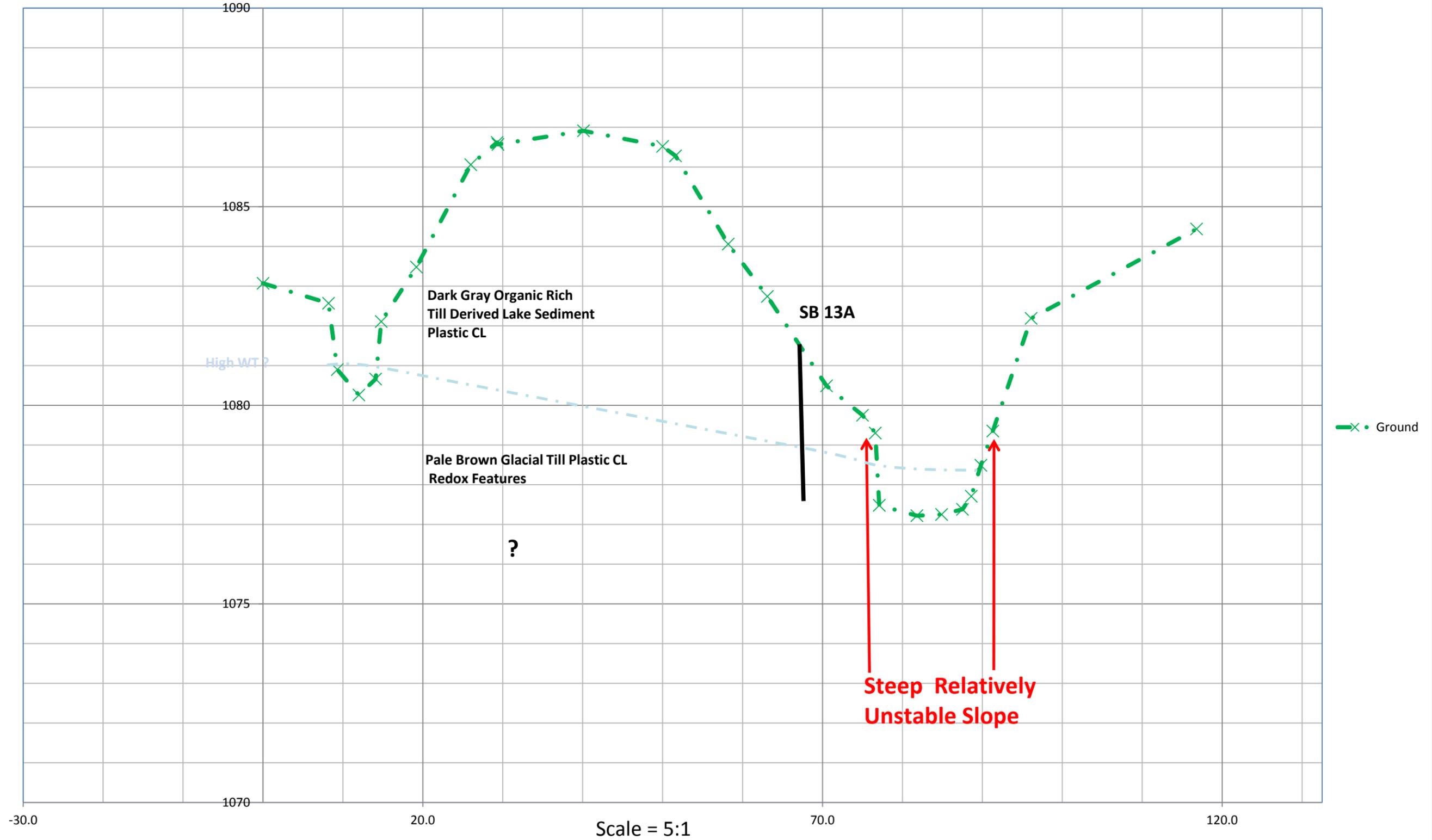
Cross Section at station 14023 (ft)



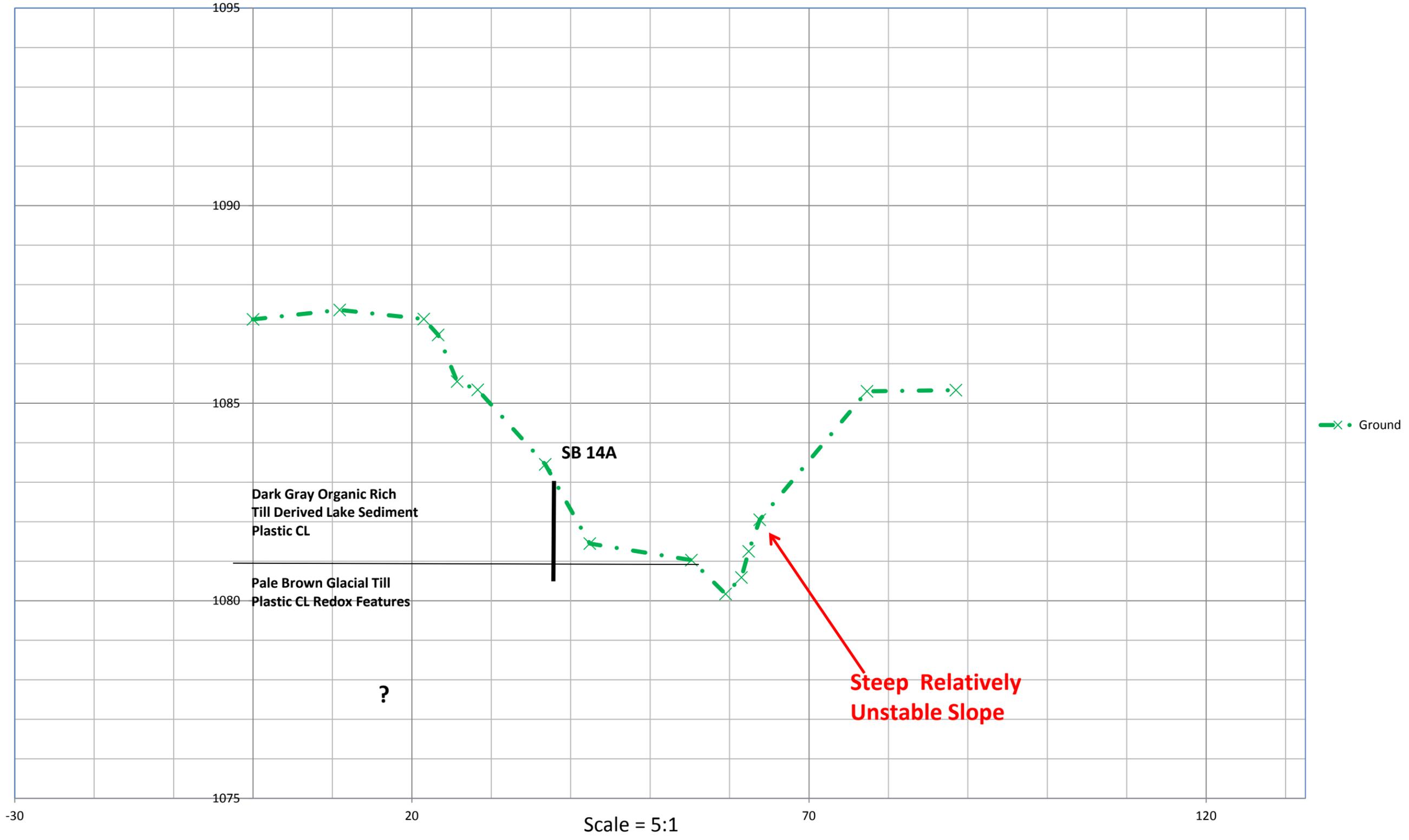
Cross Section at station 14989 (ft)



Cross Section at station 15614 (ft)



Cross Section at station 17225 (ft)



Cross Section at station 18435 (ft)

