Summit
Environmental Consultants, Inc

summitenv.com

February 1, 2013

Lamoine Planning Board
Lamoine, Maine

RE: Response to Public Comments Concerning the Harold MacQuinn, Inc. Gravel Extraction Site Plan Review Application

Planning Board Members:

Prior to and during a January 8, 2013 Public Hearing a number of written and verbal comments were presented by interested citizens related to the subject Gravel Extraction Application. Comments were raised both in support of and in opposition to the application.

Above all, it should be noted that contrary to Mr. Brutsaert's comments, Summit and the Applicant are well aware that the Cold Spring drinking water source is of great importance to the Town of Lamoine and that the Applicant would not have gone forward with this Application if adverse impacts to the Cold Spring would occur as a result of the project.

Of particular concern to the Applicant was inaccurate and misleading information presented in comments provided by Willem Brutsaert in a January 2013 letter (copy attached). In his letter, Mr. Brutsaert ignores a number of critical Geologic features, makes a number of incorrect interpretations and makes several statements that are contrary to sound geologic and engineering practices.

The manner in which Mr. Brutsaert's comments are arranged makes it difficult to respond to each "comment" in a concise fashion, however, we have attempted to separate our responses to track the section headings in his letter. Since groundwater flow patterns in the vicinity of the Kittridge Pit are controlled by surficial geology, we have started this response by first discussing comments related to the surficial geology and geological cross sections.

Before we begin, it is worth noting that the Planning Board may be misled into thinking that Mr. Brutsaert's comments poise a credible challenge to the groundwater information presented in the Application, since Mr. Brutsaert is an engineer and past professor of engineering at the University of Maine, Orono. However, the Summit staff that conducted the field investigations and prepared the Hydrogeologic Assessment of the site are well accomplished Certified Geologists and Licensed Hydrogeologists with a combined 45 years of experience throughout Maine and the East Coast of the United States in the science of applied geology and hydrogeology.

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Schematic Geologic Cross Sections:

In this section Mr. Brutsaert states "Sections A-A' and B-B' are indeed schematic and do not reflect the boring logs information provided by…." And goes on to question the validity of Summit's cross sections and understanding to the hydrological setting.

Response:

Geologist have spent the last two centuries examining present-day depositional environments and applying that information to understanding the environment in which older deposits were formed (i.e.; the key to the past is in the present – Principle of Uniformitarianism). Based on studies of current depositional environments, geologists have found that gravel, sand, silt, and clay deposits are formed in drastically different depositional environments. Gravel is deposited in high energy environments (streams and rivers). Silts and clays are deposited in low energy environments (deep water ocean/lake environments). Sands are deposited in the intermediate depositional environments (river/stream delta, near shore environments and beaches). The other key geological principle used to interpret subsurface geology is the law of superposition (or the principle of superposition), which states that sedimentary layers are deposited in a time sequence, with the oldest on the bottom and the youngest on the top.

The Maine Geological Survey (MGS) used these key Geological Principles and standard geological outcrop mapping techniques to develop the Surficial Geology Map depicting the Site and surrounding area. To a well-trained geologist, the MGS Surficial Geology map contains an enormous amount of the information that, with the aid of basic geological principles, can be used to interpret the subsurface geology of a Site with a limited number of observational borings contrary to the method of investigation suggested by Mr. Brutsaert (Recommendation #1).

A well-trained geologist can glean a wealth of information from the MGS Surficial Geology Map by examining the mapped pattern of geological units and reviewing the map legend which not only serves as a key to the name and composition of the geological units, but also serves as a timeline for the sequence of deposition. The geological history of the surficial geology of the area was discussed in the Application and is reiterated herein to provide background information that will be utilized to address Mr. Brutsaert's comments.

The sand and gravel deposit underlying the existing and proposed expansion of the Kittridge Pit is the remnant of a glacial melt water stream (esker, map symbol Pge) and the sand and gravel delta (map symbol Pmdf) that formed where the stream discharged sediments to the ocean. As the glaciers melted and receded to the north, the glacial meltwater stream deposits (esker) and the sand and gravel delta that developed at the terminus of the stream were abandoned and the depositional environment in this area changed to a deeper open water depositional environment. During this time the silt and clay of the Presumpscot Formation was deposited in low lying areas surrounding the sand and gravel deposits. Along the fringes of the low lying areas, the Presumpscot silt and clays were deposited above the delta/stream deposits. As the glaciers receded further northward, another depositional environment became dominant as sea level dropped relative to the ground surface (isostatic rebound). Under these conditions, the exposed top and sides of the delta were eroded and/or reworked by wind and water, resulting in the deposition of sandy marine "near shore" deposits on top of the Presumpscot Formation and delta/stream deposits.

Summit prepared the schematic geological cross sections presented at the Planning Board meeting based upon the MGS maps; field reconnaissance in former and active gravel pits to the south of Mill Road; and surficial materials and ground water elevations information from monitoring wells installed on the Site and former/active gravel pits locate to the south of Mill Road; as well as the elevation of the seepage areas associated with Cold Spring. The relationships between geological units and water table elevations presented on the cross sections serves as a visual representation of what is typically referred to as a hydrogeological conceptual site model.

Based upon Mr. Brutsaert's comments related to the geological cross sections and water level elevations that are scattered throughout his comments, it is clear the Mr. Brutsaert has not examined the MGS Map carefully or does not understand the geologic principles/processes that Summit used to develop the cross sections and the hydrogeological conceptual site model.

Current Observation Wells

In this section Mr. Brutsaert states "Absolutely no information can be gleaned from 3 of the 4 observation wells on the Site...." And goes on to question relationships between Cold Spring Water Company wells and a well (MW-3-2012) installed by the applicant.

Response:

In hydrogeologic investigations, all observations are considered useful and provide data that must be explained and must fit a hydrogeological conceptual site model. As an example, two wells drilled on the subject property (MW-1 and MW-3-2012) are reported as "dry" to the depth of the bottom of the well. This is not "useless" information, but rather, clearly shows that the geologic unit is not saturated and that ground water is not present above that depth within that particular geological unit.

Observation well (OW-1) within the existing Kittridge Pit, as well as the pit itself, provide perhaps the most valuable information due to the magnitude of exposed sand and gravel. If an excavation in a sand and gravel pit extends below the water table and water is not removed by pumping (dewatering), the result is a pond. This is a basic hydrogeologic fact. The absence of a pond and the fact that OW-1 intersects the water level at a depth below the excavation, again clearly demonstrates that a water table is below the base of the excavation. Examples of this situation are present in numerous gravel pits throughout the State of Maine. The Maine Department of Environmental Protection (MEDEP) provides regulations for gravel pits that extend below the water table and that regulation includes requirements for the configuration of "ponds" resulting from the excavation below the water table. To suggest that a dry excavation within a gravel pit is useless violates accepted hydrogeologic principles.

Mr. Brutsaert's "Recommendation 1" indicated that "he" would need an excessive amount of borings and monitoring wells to understand the surficial geology and groundwater flow patterns on the Site. This is not an approach that any well-trained geologist would take at this Site, given the wealth of geological information available for the region, as previously discussed. It is worth noting that given the map pattern (extent) of the esker and delta deposits, an understanding of basic geological principles, and observation of the exposed sections of this deposit in the existing Kittridge Pit (east side of deposit), it is certain that the same materials encountered in the existing Kittridge Pit will be encountered on the west side of the deposit.

Summit's approach to understanding the geology and groundwater flow pattern in the region was to use available hydrogeological information (geology maps, boring logs, water level elevations in monitoring wells) and conduct a limited field explorations to refine/confirm the existing geologic and hydrogeologic information for the Site and surrounding area. It is worth noting that the location of well MW-3-2012 was chosen to confirm Summit's conceptual site model and data obtained at MW-3-12 are consistent with the large amount of hydrogeological information reviewed.

Figure 4 Groundwater Elevation Map

This map is totally inadequate and based on little useful information....". The comments go on to question the interpretation of water level data in the vicinity of Cold Spring.

Response:

Cold Spring is located approximately 1,000 feet beyond the eastern extent of the proposed gravel pit excavation and is located in a separate and distinct hydrogeologic setting. As previously discussed, the Presumpscot Formation was deposited after the stream/delta sediments were deposited, therefore the silt and clay layer (Presumpscot Formation) can not extend into the delta deposits, and instead was deposited around and lapping against the delta/stream deposit. Summit's cross sections and MGS maps clearly show this relationship.

Monitoring well MW-3-2012 is located near the margin of the Presumpscot Formation where it laps against the delta deposits. Saturated conditions were noted in the sand and clay immediately above the contact with the Presumpscot Formation, which is consistent with observations at Cold Spring monitoring wells. However, MW-3-2012 was drilled through the Presumpscot Formation into the underlying delta deposits to evaluate the conditions in the geological unit that would be the primary target for gravel extraction activities occurring to the west. At MW-3-2012, observations of drill cuttings indicated that the sand and gravel underlying the Presumpscot Formation was not saturated and installation of the monitoring well with a screen interval beneath the silt and clay confirm that the sand was not saturated (i.e., the well is dry). This result is consistent with the information Summit has presented in the Application to the Planning Board.

Following submission of the Application to the Planning Board, Cold Spring Water Company provided Summit with the boring/well-construction information and water level elevations for wells installed on the Cold Spring property. Review of this information indicates that monitoring wells CSW-1, CSW-2, CSW-3, CSW-4, CSW-5 and CSW-6 were installed to monitor water levels in the "near shore" sand deposit overlying the Presumpscot silt and clay. Mr. Brutsaert indicated that the water level elevations in well CSW-6 are not consistent with water level elevation in MW-3-2012, located a short distance away, and that Summit failed to address this fact in our Application. However, Mr. Brutsaert apparently failed to understand that MW-3-2012 penetrated the silt and clay unit and the fact that it is dry indicates that the CSWC wells are monitoring a "perched" water table present above the silt and clay. In summary, data from MW-3-2012 and CSW-6 are consistent MGS mapping and Summit's interpretation of hydrogeologic conditions and the cross sections showing the hydrogeological conceptual site model for the Site and Cold Spring.

The geological cross sections with monitoring wells shown have been included with this response letter to better depict this relationship to the Planning Board, as it is apparent that Mr. Brutsaert could not glean this fact from the information presented to the Planning Board.

As previously discussed, in hydrogeologic investigations, all observations are considered useful and provide data that must be explained and fit a conceptual model of a Site. At well MW-3-2012, the bottom of the well screen interval extends to an elevation of 109 feet MSL indicating that a permanent ground water table in the delta unit is present at greater depth. The elevation of Cold Spring Water Company source well is at an elevation of 131 feet MSL, indicating that ground water moving in the delta unit cannot discharge to the Cold Spring (i.e.; water does not flow uphill in an unconfined condition). This relationship indicates than an alternative source of groundwater must be supporting the Cold Spring.

The location of the Cold Spring Well is coincident with a location at which "near shore" sand deposits pinch out over the Presumpscot silts and clays. Springs, seeps and wetlands are observed all along the western margin of the Archer Brook valley. These relationships indicate that Cold Spring is not a discrete area of ground water discharge to the surface. In fact, the "Cold Spring Well" is located along a long linear seepage area coincident the location where "near shore" sand deposits pinch out over the Presumpscot silts and clays. In summary, careful examination of observation wells installed by the Cold Spring Water Company and the Applicant clearly show that ground water contributing to the Cold Spring is migrating within sand deposited on top of the Presumpscot silt and clay. Therefore, the ultimate source of water contributing to Cold Spring can not be within the stream/delta deposits that underlie the Presumpscot silt and clay.

The hydrogeology of this area indicates that the source of the water to the Cold Spring is groundwater migrating in the "near shore" deposits overlying the Presumpscot silt and clay. Review of the MGS maps indicate that a large area of "near shore" deposits is present to the south and southwest west of the Cold Spring and that these deposits are hydraulically connected to a large wetland area and the headwaters of Archer Brook. Water level elevations in the large wetland area (137 feet MSL) and monitoring wells (138-139 feet MSL) in the reclaimed gravel pit located south of Mill Road are substantially higher than the Cold Spring seepage area (131 feet MSL). Groundwater elevations in the extensive area of "near shore" deposits to the south and southwest of the Cold Spring Well, therefore represent the predominate source for groundwater utilized by the Cold Spring Water Company.

It should be noted that recharge to the Cold Spring seepage area is occurring from precipitation over the area of influence to the spring. During non-drought years, the area is sufficient to sustain spring flow, but would be expected to respond (increased or decreased flow) to prolonged wet and dry periods. Anecdotal information from a local person providing comments at the Public Hearing suggests that the spring flow had diminished during a prolonged dry period a number of years ago, which is consistent with Summit's hydrogeological conceptual site model and contrary to Mr. Brutsaert's assertion of "strong and constant" flow.

Discussion Statements:

In this section Mr. Brutsaert provided comments based upon his limited understanding of the hydrogeology of the area. In the previous sections, we have described how Mr. Brutsaert's assumptions are not consistent with basic geological principles and Summit's hydrogeological conceptual site model. To be thorough, we will also respond to Mr. Brutsaert's discussion and conclusion statements.

Response:

Mr. Brutsaert's interpretation (Discussion Item #1) suggests that complex layering of deposits resulting from entrapped ice is responsible for the Cold Spring seepage area. The surficial geology map, topography, and geologic conditions present during the formation of the stream/delta deposits do not indicate that ice-contact deposits such as those implied by Mr. Brutsaert (i.e.; kettles) are present. In fact, as previously discussed, while the surficial geology of the area is "somewhat complex" it is not necessary to invoke complex geologic conditions to explain the hydrogeological conditions responsible for the Cold Spring seepage area.

Mr. Brutsaert's interpretations (Discussion Items #2, #3, and #4) are based on his misunderstanding of the hydrogeology of the area, and make no sense in the context of Summit's cross sections and hydrogeological conceptual site model, which were developed based upon sound geological principles and the hydrogeological information from MGS maps and wells and borings in the area.

Conclusion Statements:

Mr. Brusaert's conclusions were as follows:

1. *There is insufficient information to construct a credible seasonal high water table or a bedrock topography map.*
2. *Cold Spring is hydraulically connected with the Kittridge sand and gravel deposit which is the recharge area of Cold Spring*
3. *If the gravel pit will be developed as planned, Cold Spring will stop flowing.*

Response to Conclusion #1:

The generalized bedrock surface shown on Summit's cross sections is based on the typical Peninsula setting common along coastal Maine and is consistent with basic principles of glacial geology. However, it must be noted that the bedrock surface depiction is irrelevant to the hydrogeologic setting associated with Cold Spring and the proposed gravel pit.

The sand and gravel deposit targeted for gravel extraction was formed by glacial processes that are well understood. A similar deposit (map unit symbol Pmdb) is present to the south (Gott Pit). Because sand and gravel deposits are normally very permeable, a water table within the sand and gravel typically exhibits a gentle slope (gradient). The water table gradient within the deposit can be interpreted to be consistent between data points within the unit. As a result, a limited number of data points were used to estimate the water table within the sand and gravel deposit.

Summit's interpretation of the location of the seasonal high water table in the sand and gravel deposit is based on data from on-site observation wells, geologic mapping, the permeability of sand and gravel relative to silt and clay, and observations of the extensive exposures of the deposit at the existing Kittridge Pit. It also must be stressed that the Lamoine Mineral Extraction Ordinance requires that the Applicant annually demonstrates that a minimum 5 feet of separation exists between the pit floor and the water table to maintain compliance with Town requirements. As a result, an "exact" interpretation of water level location at all points within the proposed pit is not necessary, provided that on an annual basis, the applicant demonstrates the minimum separation from ground water is maintained. Nonetheless, Summit's depiction of the groundwater table is based on sound hydrogeologic principles and the available data.

Approval of and excavation of sand and gravel from the proposed sand and gravel pit will not have an adverse effect on Cold Spring. Furthermore, the Lamoine Mineral Extraction Ordinance prohibits excavation below the ground water table, regardless of its location. Therefore, since extraction activities are prohibited from below the water table, there is no basis to suggest that the gravel pit will have an adverse effect to groundwater resources if operated in accordance with the Lamoine Mineral Extraction Ordinance.

Response to Conclusion #2 and #3:

As previously discussed, Mr. Brutsaert's interpretation that the proposed sand and gravel pit is within the contributing area to the Cold Spring is based on his misunderstanding of the hydrogeology of the area, and is not consistent with Summit's cross sections and hydrogeological conceptual site model, which were developed based upon sound geological principles and the hydrogeological information from MGS maps and wells and borings in the area.

The Delta sand and gravel deposit is not hydraulically connected to Cold Spring. Cold Spring is the result of ground water moving through overlying "near shore" sand deposits on top of the underlying silt and clay Presumpscot Formation and discharging where the sand pinches out. Excavation of sand and gravel within the Delta deposit that is above the water table will not result in adverse effect to the Cold Spring Water Well, nor will it cause Cold Spring to stop flowing.

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Enclosures

January, 2013

Hydrogeologic Assessment, prepared by Summit Environmental Consultants, Inc. for Harold MacQuinn, Inc.

Reviewed by

Willem Brutsaert[1]

Introduction: On 4 December, 2012, Summit Environmental Consultants gave a presentation to the Lamoine Planning Board regarding the MacQuinn, Inc. application of a gravel pit expansion of the so-called Kittridge pit, located along the east side of Rt. 184. Brutsaert was present as an interested citizen of Lamoine. At that meeting it was learned that the floor (bottom) in the middle of the proposed new pit was going to be at about 70 feet above MSL, whereas the water elevation of Cold Spring is at about 131 feet above MSL. This raised immediate concern as Cold Spring may be an integral part of the regional hydrology of this sand and gravel deposit. Brutsaert decided to further investigate because he thought that the results presented by Summit seemed arbitrary and based on insufficient data, thus conjecture. What follows is a summary of his findings.

Current observation wells. Absolutely no information can be gleaned from three of the four observation wells on site, as far as a seasonal high water table base line (or benchmark) is concerned.

- OW1 should not be included in establishing a water table base line. Its water level is compromised by the existing gravel pit in which it is located. New credible observation wells should be established away from the pit.
- MW1 and MW3 are useless, unless finished beyond current depth. It is likely that the existing marine silt/clay 'lens/layer', as evidenced by the bore logs, acts as a (semi)-confining layer (aquitard), thereby causing (semi)-artesian conditions.
- MW2 is the only useful observation well with a credible water level.

Completion of MW1 and MW3 may provide some answers, not speculative information.

- Apart from MW2 there is no information on which to base or construct a meaningful water table map (see below).
- The fact that MW3 came out dry and that CSW-6, an observation well of the Cold Spring water company and located within view of MW3, recorded a water level at 135.4 ft., seems a bit of a paradox and begs for an explanation. MW3 was first drilled down to 65 ft. bgs and was abandoned "due to driller error" (the bottom 15 ft. of augers were left in the hole). A new MW3 was drilled next to it, but only down to 55 ft. bgs. CSW-6 is drilled down to 50 ft. Why is MW3 dry and CSW-6 not?

[1] Willem Brutsaert, Ph.D., Professor Emeritus of Civil and Environmental Engineering, University of Maine. Since 1973 he taught courses at Umaine in Fluid Mechanics, Hydrology, Groundwater Hydraulics and Hydrology, Open Channel Hydraulics, and Groundwater Systems Modeling. He has been a consultant hydrologic engineer in Belgium, Germany, North Africa, Colorado, New Mexico, and Maine. He was principal investigator of several projects dealing with both quantitative and qualitative aspects of groundwater management, and received an AWWA "Best Paper" award for his pioneering research on Radon in groundwater.

Recommendation 1: In light of the fact that this is a large project (>100 acres) with potentially negative effects (see below) due to profound changes of the regional groundwater flow, I strongly recommend that at least an additional ten observation wells (piezometers) be constructed at critical points around the property in order to establish the seasonal high water table, thus before any excavation starts, and that split spoon samples be taken at regular intervals as part of the standard boring log protocol.[2] I recommend that these monitoring wells/piezometers be located along the east-west centerline of the proposed pit area, and along two north-south running lines, one across the top, the other half way down toward the east.

Figure 4, Groundwater Elevation Map:
This 'map' is totally inadequate and based on little useful information provided by OW1 and MW2. Conclusions on page 78 of the Summit report are therefore misleading.
- The two westward pointing arrows shown within the gravel pit area (previously permitted and proposed) are more or less right for the western side of the sand and gravel deposit, but wrong for the eastern side. As can be deduced from the topographic map, there is a groundwater divide (similar in concept to a continental divide as far as flow is concerned) running to the north from MW1, to the east-southeast and to the west-southwest from MW1, because MW1 is close to the high point of the sand and gravel deposit. Regional groundwater table topography generally mimics, in subdued form, the ground surface topography, which is an immutable law of regional groundwater flow.
- The two northward pointing arrows on the map, one just south of Cold Spring, and the other north of Cold Spring indicating a northerly direction of flow, are again speculative and wrong. Based on available information, which consists of the 6 observation wells of the Cold Spring Water Company and another spring (water level 137.7 ft.) about 250 ft. to the NNE of MW3 causing a small wetland area, it is clear that Cold Spring is hydraulically connected with the regional groundwater flow from the west-northwest, thus from the proposed gravel pit area. In fact, water level data show that the gradient of groundwater flow around the Cold Spring area has a strong component to the east and a weak one to the south.

Recommendation 2: The seasonal high water table is the most critical piece of information on which the engineer bases the design of the pit. What is needed here is a credible groundwater table map, showing contours connecting with surrounding surface water features (springs, bogs, ponds, brooks, etc.) and based on credible observation wells on the property (see recommendation 1).

Schematic geologic cross-sections:
Sections A-A' and B-B' are indeed schematic and do not reflect the boring log information provided by (incomplete) MW-1 and MW-3. There is no credible data to suggest an east to west slope of the bedrock topography, or a near horizontal north-south bedrock topography, let alone the "suggested" depth to bedrock. In order to establish a credible bedrock topography, any new observation wells must be drilled down to 'refusal'.

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[2] DEP regulations require that "at least one test pit or monitoring well be established on each five acres of unreclaimed land" (Title 38 M.S.R.A., Chapter 3 §490-D, 3. Groundwater protection). I assume that "unreclaimed" lands refer to lands after excavation.

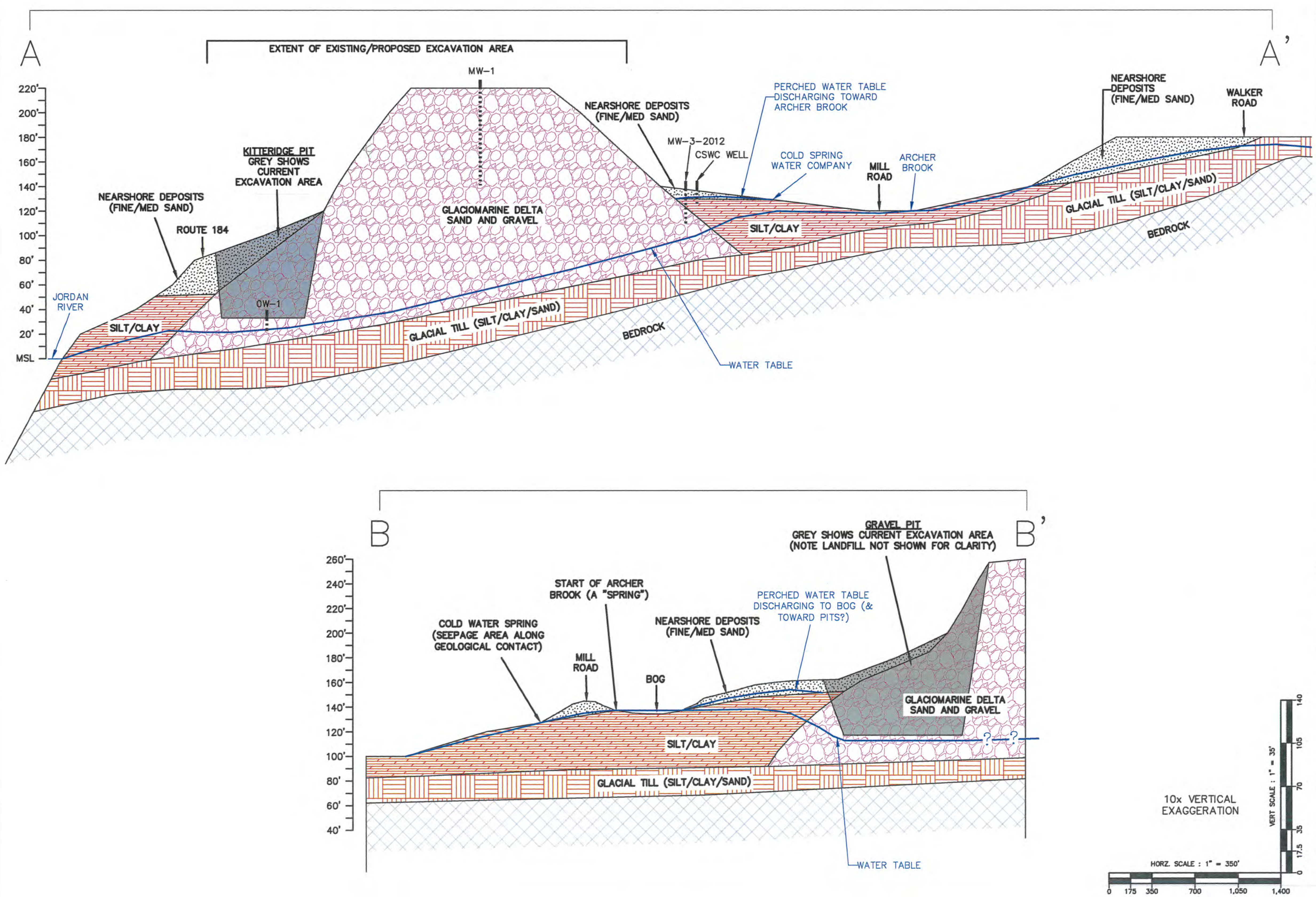
Worse is the position of the water table on that same A-A' cross-section, shown as a more or less straight line between OW1 and MW2 and sloping down from east to west.

Discussion

1. Cold Spring is an expression of and controlled by regional groundwater flow from the west-northwest, thus the Kittridge sand and gravel deposit, hydrologically called the 'recharge' area. The "pinching" confining conditions of the marine clay/silt 'lens' extending to the west-northwest from Cold Spring may possibly enhance the flow. The origin of this lens/layer could be due to a remnant ice pocket (entrapped ice), which later filled in with marine clay/silt during the period of marine submergence, but is more likely a remnant of the Presumpscot formation (clay/silt), also deposited during that same period of marine submergence. The geology is obviously very complex due to repeated cycles of a retreating and advancing ice front.
2. Since the sand and gravel deposit just west-northwest of Cold Spring is the recharge area, a 'protection zone' around Cold Spring would extend far upstream into the recharge area, thus to the west-northwest, at least as far as the groundwater divide. There is no point in protecting Cold Spring downstream from it. Therefore, a protection zone consisting of a circle around Cold Spring does not make sense. The Cold Spring Water Company would be well served by establishing such a "protection zone.
3. Cold Spring is and has been a steady strong-flowing spring, also during periods of prolonged drought. If Cold Spring were fed from the south or by a 'perched' water table, as suggested on Cross-section A-A', flow would be intermittent, thus low flow or no flow at times of prolonged drought. Thus the flow of Cold Spring is as explained in point 1 of this discussion.
4. If the gravel pit were to be developed based on a straight-line interpolation between the two water levels of OW1 (23.3 ft.) and MW2 (86.6 ft.), Lamoine can say goodbye to the Cold Spring Water Company. The water level of Cold Spring is at 131 ft. The bottom of the proposed pit near its center will be at about 70 ft. with a water table 5 ft. below that. The result is that all water would now drain to that central area and likely form a pond. Even if the sand and gravel would only be taken down to 140 ft., there would not be enough hydraulic head to keep Cold Spring flowing. Thus a gravel pit in the proposed area, which is the recharge area of Cold Spring, should not be constructed if one wants to preserve its flow.

Conclusions:

1. There is insufficient information to construct a credible seasonal high water table or a bedrock topography map.
2. Cold Spring is hydraulically connected with the Kittridge sand and gravel deposit which is the recharge area of Cold Spring.
3. If the gravel pit will be developed as planned, Cold Spring will stop flowing.



NO.	REVISION	DATE
1	ADDED MONITORING WELLS	2/1/13

SHEET TITLE: SCHEMATIC GEOLOGICAL CROSS SECTIONS

SCALE: AS NOTED | DRAWN BY: SBM

DATE: DEC. 2012 | CHECKED BY: MAD

PROJECT: KITTRIDGE PIT ROUTE 184 LAMOINE, MAINE

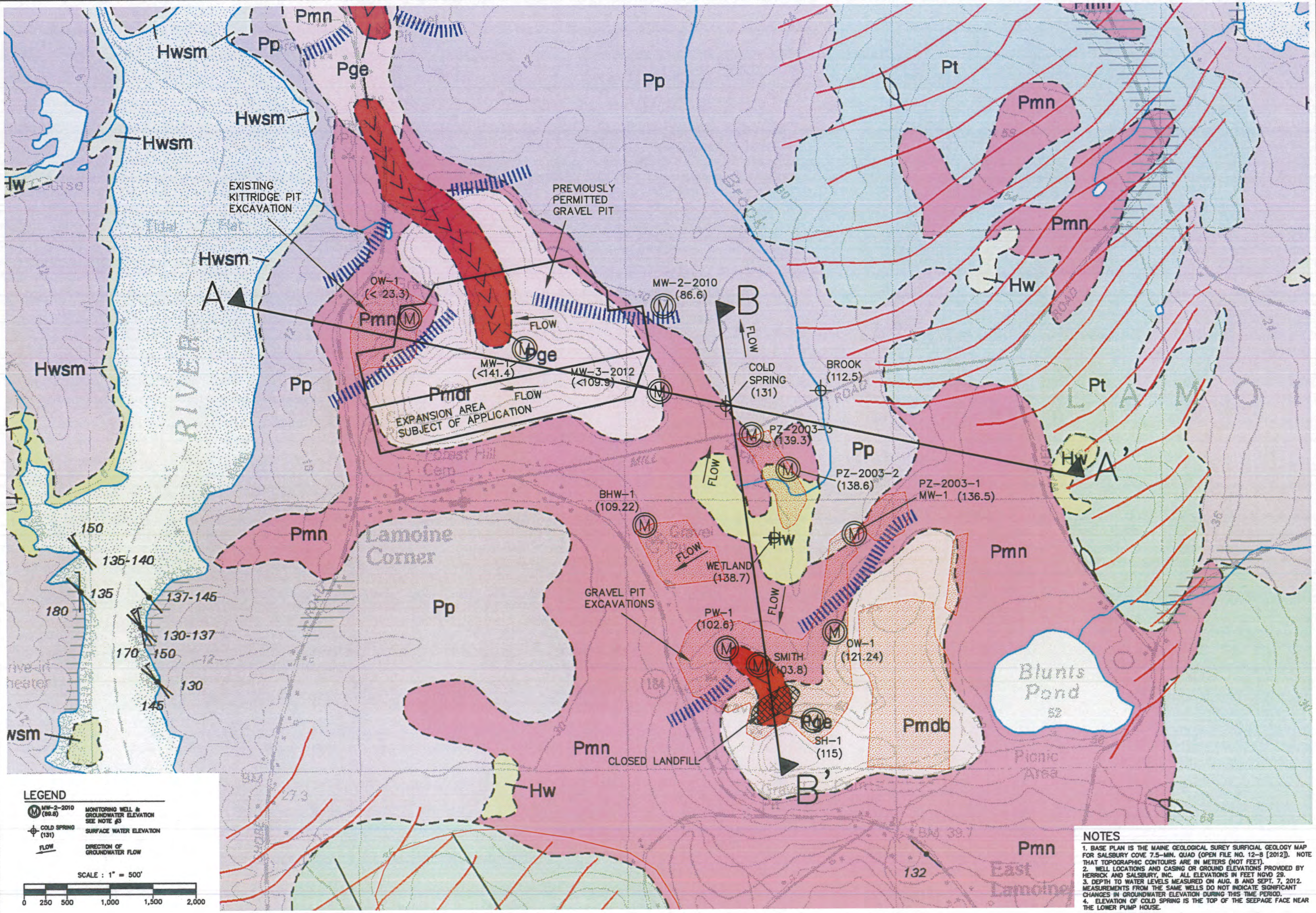
CLIENT: HAROLD MACQUINN, INC. PO BOX 789, ELLSWORTH, ME 04605

640 MAIN ST. LEWISTON, MAINE 04240 Tel.: (207) 795-6009 Fax: (207) 795-6128 www.summitenv.com

Summit Environmental Consultants

JOB NO: 11-3240.5

FOR PLANNING BOARD PRESENTATION



NOTES

1. BASE PLAN IS THE MAINE GEOLOGICAL SUREY SURFICIAL GEOLOGY MAP FOR SALSBURY COVE 7.5-MIN. QUAD (OPEN FILE NO. 12-8 [2012]). NOTE THAT TOPOGRAPHIC CONTOURS ARE IN METERS (NOT FEET).
2. WELL LOCATIONS AND CASING OR GROUND ELEVATIONS PROVIDED BY HERRICK AND SALSBURY, INC. ALL ELEVATIONS IN FEET NGVD 29.
3. DEPTH TO WATER LEVELS MEASURED ON AUG. 8 AND SEPT. 7, 2012. MEASUREMENTS FROM THE SAME WELLS DO NOT INDICATE SIGNIFICANT CHANGES IN GROUNDWATER ELEVATION DURING THIS TIME PERIOD.
4. ELEVATION OF COLD SPRING IS THE TOP OF THE SEEPAGE FACE NEAR THE LOWER PUMP HOUSE.

NO.	REVISION	DATE

SHEET TITLE: SURFICIAL GEOLOGY MAP & GROUNDWATER ELEVATIONS

SCALE: AS NOTED
DATE: DEC. 2012
DRAWN BY: SBM
CHECKED BY: MAD

PROJECT: KITTRIDGE PIT
ROUTE 184
LAMOINE, MAINE

CLIENT: HAROLD MACQUINN, INC.
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JOB NO: 11-3240.5

FOR PLANNING BOARD PRESENTATION

af — **Artificial fill** - Includes landfills, highway and railroad embankments, and dredge spoil areas. These units are mapped only where they are resolvable using the contour lines on the map, or where they define the limits of wetland units. Minor artificial fill is present in virtually all developed areas of the quadrangle.

Hms — **Marine shoreline** - Sand and gravel on modern ocean beaches.

Hw — **Freshwater wetlands** - Muck, peat, silt, and sand. Poorly drained areas, often with standing water.

Hwsm — **Saltmarsh wetlands** - Peat, muck, silt, and clay. Coastal marsh, subject to tidal flooding. Thin, non-commercial peat layers are present atop a mineral substrate consisting of estuarine sands and muds.

Pmd — **Marine delta** - Pleistocene marine delta formed during flooding by the sea due to isostatic emergence of the land. Very low-angle sand and silt foreset bedding is mantled by trough cross-bedded sand, deposited by braided streams which flowed over the delta top as it prograded seaward. In places, may be mantled with unmapped thin eolian deposits. Two deltas have been assigned unique geographic names listed below:

Pmdf - Forest Hill delta
Pmdb - Blunts Pond delta

Pmn — **Marine nearshore deposits** - Pleistocene gravel, sand, and mud deposited as a result of wave activity in nearshore or shallow-marine environments; not associated with beach morphology.

Pp — **Presumpscot Formation** - Massive to laminated silty clays with rare dropstones and occasional shelly horizons, which overlie rock and till, and are interbedded with and overlie end moraines and marine fan deposits; includes sand deposited as a distal unit of submarine fans.

Pem — **End moraines** - Linear ridges consisting of bedded sand and gravel interbedded with Presumpscot Formation silty clays and overlain by till on the ice-proximal faces of the moraines. One moraine has been assigned a unique geographic name listed below:

Pemlh - Long Heath end moraine

Pmf — **Submarine outwash fans** - Thick sand and gravel accumulations formed at the mouth of subglacial tunnels along the receding late Pleistocene ice margin. The sand and gravel is interbedded with and overlain by Presumpscot Formation clays at the distal edges of the fans, and interlayered with and overlain by tills at their ice-contact faces.

Pge — **Esker** - Ridges of massive to stratified, commonly interbedded, sand and gravel. Deposited by meltwater streams in subglacial and englacial conduits during retreat of the last ice sheet.

Pt — **Till** - Light- to dark-gray nonsorted to poorly sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders, a predominantly sandy to silty diamicton containing some gravel. Generally found under most other deposits.

Ptd — **Thin drift, undifferentiated** - Areas of thin patchy sediment cover on bedrock, which are unmapped or have few exposures of surficial materials. The sediments may include till, Presumpscot Formation, and/or marine nearshore deposits.

Bedrock outcrops/thin-drift areas - Ruled pattern indicates areas where bedrock outcrops are common and/or surficial sediments are generally less than 10 ft thick. Mapped from air photos and ground observations. Actual thin-drift areas probably are more extensive than shown.

Areas of disturbed land - Active or inactive quarries and excavations. Topography of these areas has been obscured by mining operations.

Contact - Boundary between map units.

125 165 — **Striations** - Observations made at dot. Number indicates azimuth (in degrees) of ice-flow direction. Where two directions are observed in the same outcrop, flags indicate older trends where discerned. Where present, arrows on striation lines indicate a unique flow direction. (Sh) after azimuth number indicates striations from Shaler, 1889. (L) after azimuth number indicates striations from Lowell and Borns, 1988.

125 — **Crescentic fractures** - Observations made at dot. Number indicates azimuth (in degrees) of ice-flow direction. Crescent mark indicates direction of ice flow. These features are the result of friction from boulders in the base of the ice passing over the bedrock and gouging the rock surface, leaving the crescent-shaped fractures, oriented near perpendicular to ice-flow direction.

End moraine crests - Line shows crest of moraine ridge deposited along the retreating margin of the most recent glacial ice sheet.

>>>>> — **Esker ridge** - Shows trend of sand and gravel ridge deposited in a meltwater tunnel within or beneath glacial ice. Chevrons indicate direction of meltwater flow.

Ice-margin positions - Shows an approximate position of the glacier margin during ice retreat based on meltwater deposits, moraines, or positions of meltwater channels.

Drumlin - Glacially streamlined hill. Symbol shows long axis of hill or ridge shaped by flow of glacial ice, and which is parallel to former ice-flow direction.

Glacially grooved or fluted till - Formed beneath the glacier by erosion of till surfaces by boulders in the base of the ice scouring the till, or by obstructions on the till surface that allow for development of elongate till ridges parallel to ice-flow direction.

Wave-cut scarp - Formed during the recession of the glacial sea.

Upper limit of marine submergence - Shows highest elevation of sea level immediately following recession of the last glacial ice sheet from the quadrangle. The two deltas in Lamoine in the northern half of the map are at elevations of approximately 263 ft (80 m) to 250 ft (76 m), marking the highest level of the sea to which the deltas were deposited. The blue dashed lines show the areas where islands would have been found in the glacial sea, approximately 15,000 years before the present.

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