

Surficial Geology Map & Recharge Potential of the North Bennington Through Old Landfill Region

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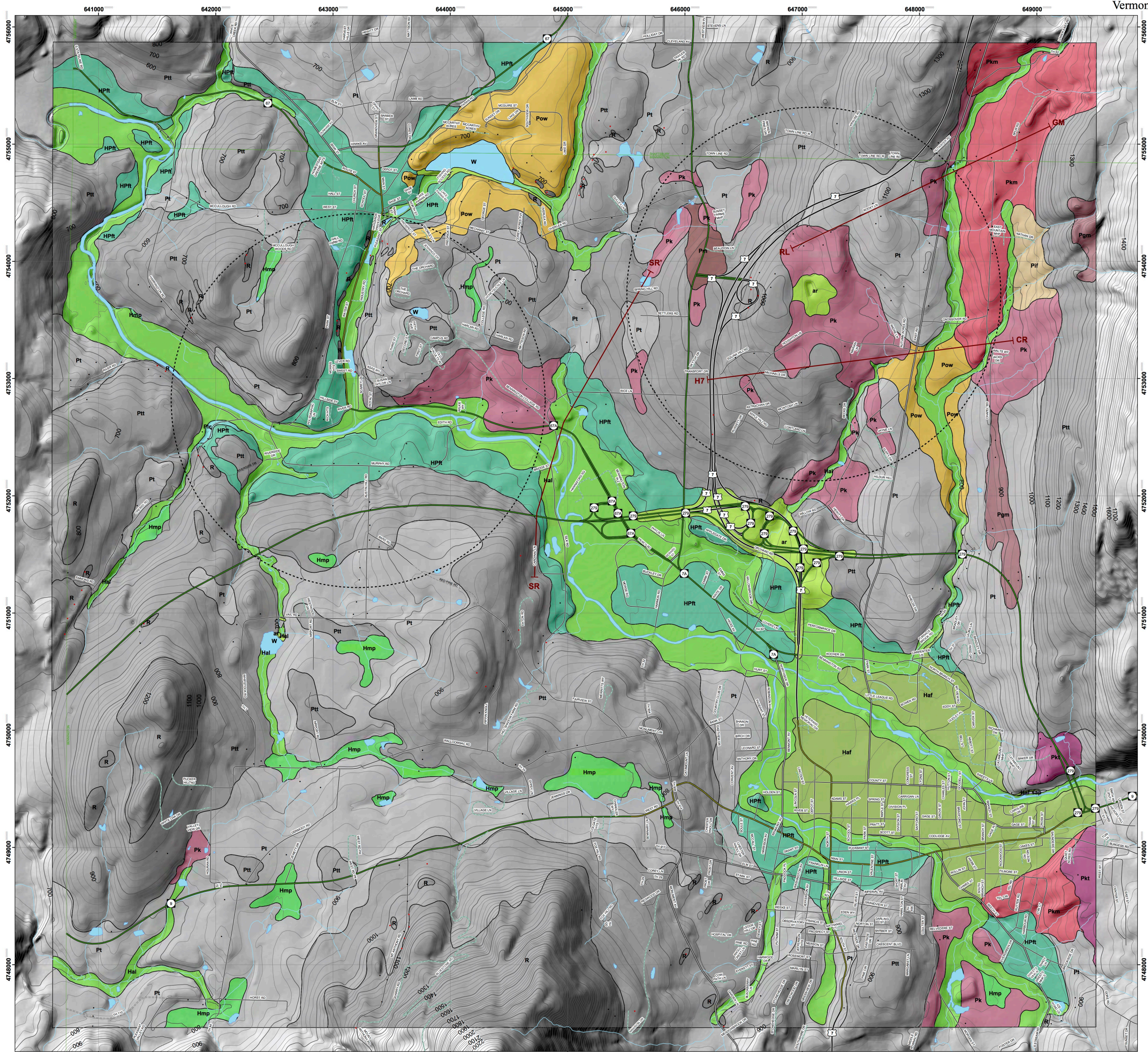
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**Vermont Geological Survey open file report VG2017-1
Vermont Agency of Natural Resources Contract #32310**

submitted 26 December 2016

Goals

- > Complete 1:12,000 surficial geologic mapping of designated area largely within Bennington quad but edging into Hoosick Falls, Pownal and North Pownal quads.**
- > Interpret the Late Pleistocene through Holocene landscape evolution.**
- > Analyze ChemFab borings and work with Jon Kim, Emmet Norris & Peter Ryan to construct a fence diagram of that contaminated site.**
- > Use well logs to construct cross sections in the Old Landfill area & through any other places of interest.**
- > Generate aquifer recharge potential maps of the ChemFab & Old Landfill areas to aid in understanding downward movement of PFOA through overburden.**



Description of Map Units	
Recent	
ar	Artificial Fill. Variable materials used as artificial fill along rail beds, road beds, embankments and low lying areas. Large areas of fill are commonly shown on the map. Small areas of fill and areas along rail lines are not shown.
Holocene	
Hmp	Muck-Peat. Organic sediment. Primarily silt and clay in wetlands and swamps. Deposits are located in low lying flat lands that are prone to flooding.
Hal	Alluvium. Fine sand, silt and gravel, stream flood plain deposits of river channel, bar, and overbank areas. Deposits usually have intermediate to low permeability but can be a good aquifer if sufficiently thick. Surface sediment may be poorly drained overbank silt or well drained channel and bar sand and gravel.
Haf	Alluvial Fan. Gravel, silt and sand, often poorly sorted, includes diamicton. Moderately sloping tributary stream deposits located at the base of steep slopes and at stream junctions. Deposits usually have intermediate to low permeability but can be a fair aquifer if sufficiently thick and permeable.
Holocene/Pleistocene	
HPft	Fluvial Terrace. Fine sand, silt and gravel generally less than 5 meters thick overlying other material. Flat to gently sloping old flood plain deposits. Deposits have variable permeability but usually intermediate. Usually serve as a fair aquifer. Banks above streams may be prone to failure.
Pleistocene	
Plc	Lake Clay-Silt. Fine grained varved or thinly laminated deposits of silt and clay accumulated in the deeper portions of lake basins. Gravel and sand lenses may be present within the sequence but especially toward the bottom. Deposits are poorly drained and form an aquitard to an aquiclude. Deposits are also are prone to landsliding and gullying.
Pif	Inwash Fan. Stratified fluvial sand, sand and gravel, or gravel. Deposited in topographic setting similar to alluvial fans but lower distal position was glacial ice and not solid ground. Deposits are well drained and, if thick, a good unconfined aquifer.
Pow	Outwash. Well sorted gravel and sand typically greater than 5 meters thick. Deposits form gently sloping to flat lands which may be pitted due to melted ice blocks. Deposits have intermediate to high permeability and are an excellent aquifer with high gravel-sand resource potential.
Pk	Kame. Stratified and unstratified sand, gravel and boulders with variable silt. Deposits form undifferentiated hummocky terrain. Comprised of glacial deposits from streams, slumps, and deposition by ice. Deposits have intermediate to high permeability, high gravel-sand resource potential, and are a fair to good unconfined aquifer, limited by variable thickness and aerial extent, which may be recharge to confined aquifer on valley floor.
Pkt	Kame Terrace. Stratified and unstratified gravel, sand, boulders and some silty sand with gravel. Ice contact melt water and sediment flow deposits that typically exceed 10 meters in thickness and form flat to nearly flat lands. Deposits have intermediate to high permeability and serve as an excellent unconfined aquifer that may be recharge to the valley floor confined aquifer. Deposits also have high gravel-sand resource potential, and slopes at edges of these areas may pose a stability problem.
Pkm	Kame Moraine. Stratified and unstratified gravel and sand with silt and boulders. Ice contact melt water and sediment flow deposits that form rolling, hilly ridged lands with local flat areas. Deposits have intermediate to high permeability, high gravel-sand resource potential, and local steep slopes pose a slope stability problem.
Pgm	Ground Moraine. Hummocky till with sand and gravel ranging from stratified and well-sorted gravel and sand to unstratified and poorly sorted silt, sand, gravel and boulders (diamicton). Ice contact sediment flow, meltwater and ice deposited sediments of variable texture that may form gently rolling or elongate hills. Deposits have low to high permeability and limited local slope stability problems.
Pm	Moraine. Unstratified and stratified silt, sand, gravel and boulders that may form a ridged or smoothly undulating landform. Ice contact, ice deposited, sediment flow, and meltwater deposited materials that form broad ridges and swales with rolling low hills. Deposits have variable permeability and local slopes may pose a stability problem.
Pt	Till. Ice-derived, unsorted, and unstratified hardpan silt, boulders, gravel and sand greater than 3 meters in thickness. Material was deposited beneath the glacier and may contain deformed stratified units that may be re-deposited diamictons from subaqueous or subglacial flows. Deposits form smoothed and streamlined hills and drumlins in the valley and gently undulating slopes on the lower mountain flanks, to nearly flat plains dotted with erratics. Deposits have low permeability and retard infiltration to bedrock aquifer. Slopes are often unstable in excavations and prone to significant slope failures along stream banks.
Ptt	Thin Till. Ice-derived, unsorted, and unstratified hardpan silt, boulders, gravel and sand less than 3 meters thick with rock outcrops or ledge frequent. Surface boulders or erratics are common. Deposits are located on moderate to steep mountain slopes and summit areas. Deposits have low permeability; however, soil formation typically improves permeability and enables recharge to bedrock aquifer. Steep slopes are unstable and slides are common.
Pre-Pleistocene	
sap	Saprolite. Deeply, thoroughly weathered bedrock altered under climatic conditions much different than today. Saprolite was observed along the Wallomsac River in several exposures opened up by Hurricane Irene. Slumping has covered some of these preserved weathering profiles.
R	Rock Outcrop. Areas of predominantly outcrop with patches of till or slump or slide debris. Outcrop areas serve to recharge bedrock units with groundwater. Slopes are generally stable except steep slopes where rock slides and rock falls may occur.

Description of Map Symbols	
Field Locations (Bedrock Outcrops)	Lakes/Ponds
Field Locations	Rivers
Area Analyzed for Recharge Potential	Cross-Sections
Town Boundaries	

Old Overlay NAD 1983 UTM Zone 18N
Base map and Contours derived from USGS 10m National Elevation Dataset.

Basic Map Elements

Flood plain = apple green
Alluvial fans = olive green
Fluvial terraces = mint green
Lake clay-silt = blue
Outwash = yellow
Ice contact sediments = shades of red-brown-pink
Till = grays
Bedrock = darkest gray

See the map on poster

Location

Surficial Geologic Map of North Bennington, Vermont

Vermont Geological Survey Open File Report VG2017-1: Plate 1

Scale 1:12,000
Contour Interval = 20 ft

0 0.25 0.5 1 1.5 2 Miles
0 0.25 0.5 1 1.5 2 Kilometers

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2017

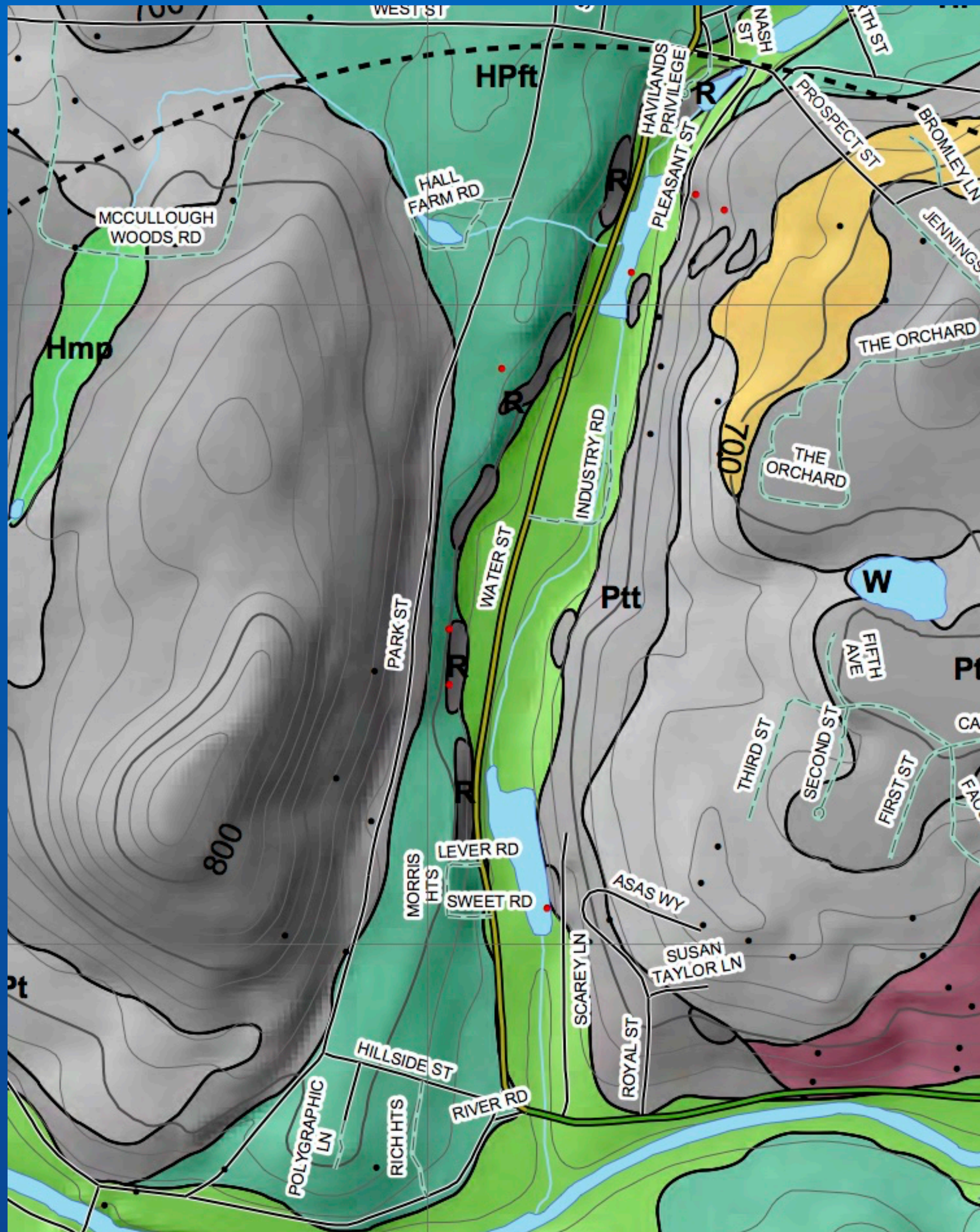
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Digital Cartography by Colin Dewey

Suggested Reference: DeSimone, D. J., 2017, Surficial Geologic Map of North Bennington, Vermont: Vermont Geological Survey Open File Report VG2017-1, Scale 1:12,000.

Landscape Elements & Pleistocene History

- > Pre-glacial landscape with probable trellis-rectangular drainage network**
- > Walloomsac Valley cuts across lithologies/structures = antecedent**
- > Deep pre-glacial Furnace Brook valley at foot of Green Mountains with thick overburden**
- > Prominent ice contact sediments in Furnace Brook valley**
- > Hale Mountain ridge constrained retreating ice northwest of Old Landfill**
- > Shaftsbury ice margin records lowering of Lake Bascom & retreat from it left local lakes (Small & DeSimone, 1993; Libbey & Pierson, 1994)**



Paran Creek Detail

- > Scoured valley walls, till with outcrop
- > Remnant 700ft outwash
- > Valley floor terraces & flood plain alluvium
- > No residual lake clay-silt

Landscape Evolution

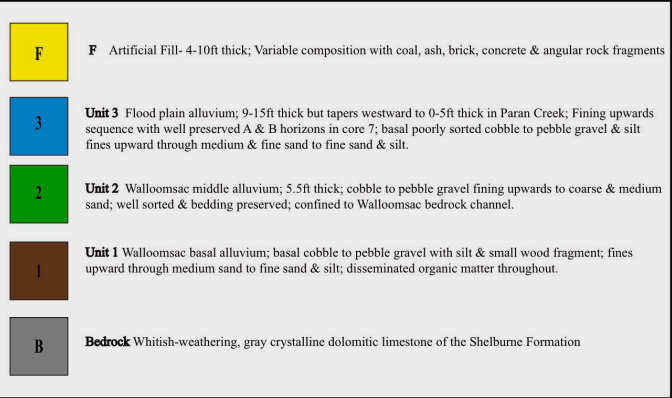
- > Ice margin to north in Shaftsbury
- > Lake Bascom drops from 900ft to lower levels including 700ft with outwash
- > Drainage of Lake Bascom causes valley floor erosion
- > Minor glacial lakes to the north drain and scour channel. (Lake Flat Top of Libbey & Pierson, 1994; Lake Emmons of Small & DeSimone, 1993)

Stratigraphy ? ...

DRAFT

Fence Diagram Correlating Surficial Materials Between Cores on the Chemfab Property

Authors:
David DeSimone (DeSimone Geoscience Investigations)
Jon Kim (Vermont Geological Survey)
Emmet Norris and Peter Ryan (Middlebury College)



KEY TO STRATIGRAPHIC SYMBOLS

F fill
BF boulder fill (log description)
ST silt
CL clay
FS fine sand
MS = medium sand
CS = coarse sand
PG = pebble gravel
CG = cobble gravel
R rock

Static Water Level

INTERPRETATION

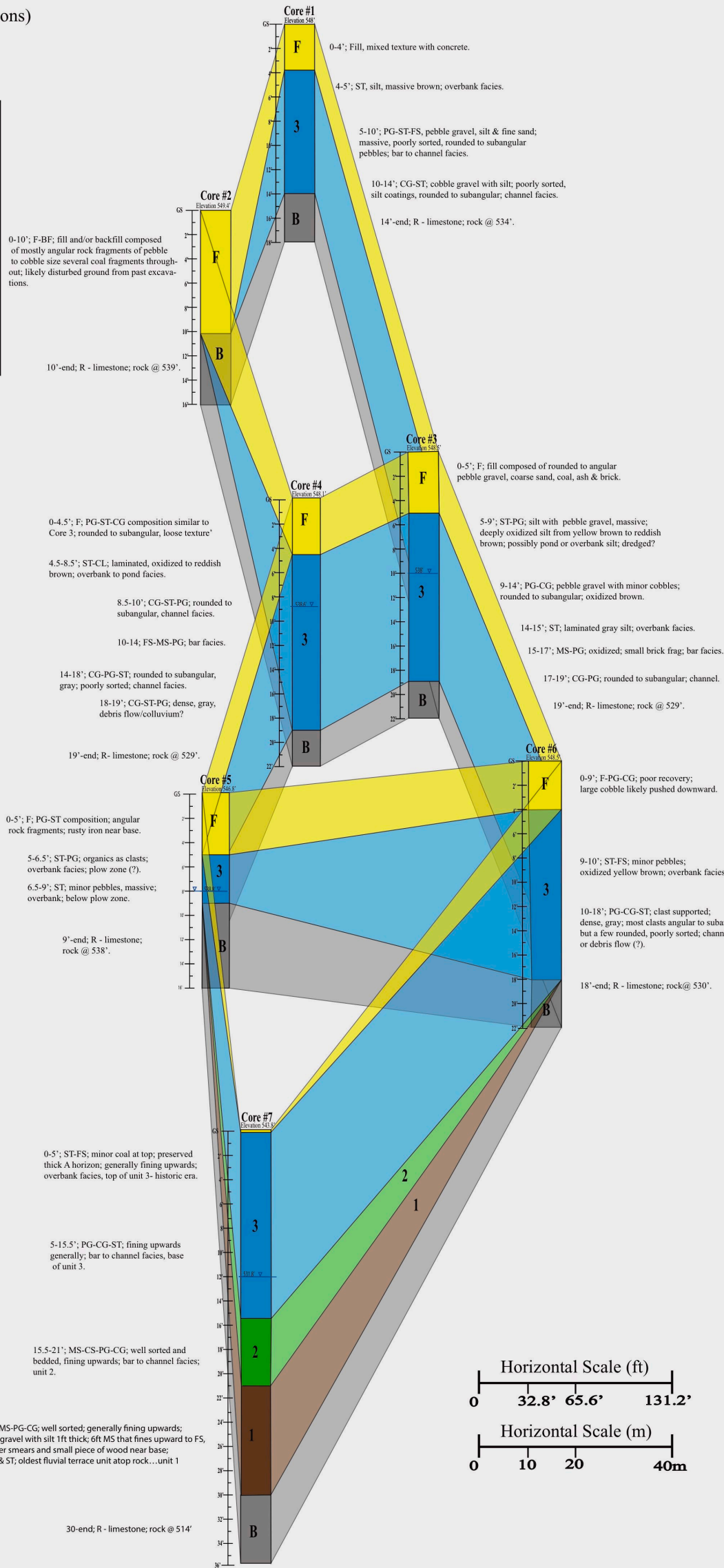
Bedrock surface: The bedrock surface generally slopes eastward and southward beneath the cores. A steep slope in the bedrock profile occurs between Core 5 and Core 7, a drop of 24ft, at the junction of the Paran and Walloomsac channels. It is not known if the slope is stepped or a continuous drop but clearly represents a bedrock nick point.

Late Pleistocene events: The Paran Creek and Walloomsac valleys experienced fluvial discharges related to glacial lake lowering and one small lake breakout. The stepped and rapid lowering of Glacial Lake Bascom from the 900ft Potter Hill level through brief bedrock controlled steps at 700ft, 665ft, 625ft and finally to ice controlled lower levels each resulted in avulsion of the Walloomsac and Paran Creek channels. Additionally, Paran Creek received the breakout flow when a small glacial lake in Shaftsbury to the north. These drainage events likely resulted in channel avulsion and erosion of any Pleistocene sediment deposited in the bedrock channels.

Holocene events: The Holocene transition was marked by rapid sea level rise from early thru middle Holocene, ~11,000-7000 years, based upon comparison of sea level curves in the literature. This was very likely a time of valley aggradation and deposition of fluvial terrace sediments atop bedrock in the area of the cores. Unit 1 & Unit 2 were likely deposited in the deeper Walloomsac channel during this time frame. The presence of an unidentifiable fragment of wood near the base of Unit 1, the oldest alluvial sequence, suggests a Holocene age. Regionally, as inferred from numerous geosarchaeology projects in the Hudson drainage basin by DeSimone, valley incision resumed likely during late middle to late Holocene time as sea level rise slowed to it's current level. Many of our local valleys have multiple fluvial terrace sequences and associated abandoned terraces that have been dated from archaeological investigations to the last 6000 years. Unit 3 likely accumulated across the Walloomsac and Paran drainages as aggradation occurred with a nearly stable sea level. Coal near the top of core 7 and a preserved plow zone inferred near the top of core 5 suggests flood plain deposition continued in the study area through historic time. Individual facies of Unit 3 in cores 1-6 may not be laterally continuous, especially any basal facies inferred to possibly represent channel lag or debris flow origins. Overbank deposits may be more laterally traceable in cores 1-6, where present. Hence, no attempt is made to draw correlation lines among facies, only fluvial terrace sediment packages.

Historic disturbances: Only core 7 preserves a complete Unit 3 without fill while cores 1-6 all show varying degrees of disturbance and addition of thick fill. Fill was likely added to the area to elevate the flood plain and minimize flooding of structures. A preserved possible plow zone in core 5 beneath fill suggests elevation of the land was accomplished with fill. In other cores, the flood plain sediments were truncated at the fill contact and soil profiles were disturbed or removed. Thus, topsoil removal may have been done prior to fill addition. The highly oxidized reddish fine-grained sediments inferred to possibly represent pond sediment may indicate these sediments date from sometime after dams were constructed along Paran Creek. Increased acidity from industrial activity, especially coal burning, may be responsible for the highly oxidized condition of these localized sediments.

*Due to poor recovery in top of Core 6, a depth of 4 ft was arbitrarily chosen to represent the base of fill. This is reasonable, based upon visual observation that suggests little fill. Core 2 fill thickness was arbitrarily chosen because the site is bracketed by deeply excavated utility lines and the material all indicated disturbance and/or fill origins to top of rock. Drilling logs in related adjacent areas to Core 2 were excavated to as much as 8ft depth. The 5 ft fill thickness chosen is consistent with fill thickness in other cores.



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ChemFab Fence Diagram

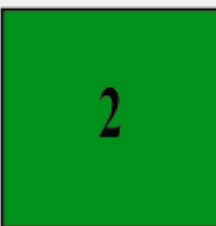
> Thin alluvium over bedrock in Paran Creek...Unit 3.



F Artificial Fill- 4-10ft thick; Variable composition with coal, ash, brick, concrete & angular rock fragments



Unit 3 Flood plain alluvium; 9-15ft thick but tapers westward to 0-5ft thick in Paran Creek; Fining upwards sequence with well preserved A & B horizons in core 7; basal poorly sorted cobble to pebble gravel & silt fines upward through medium & fine sand to fine sand & silt.



Unit 2 Walloomsac middle alluvium; 5.5ft thick; cobble to pebble gravel fining upwards to coarse & medium sand; well sorted & bedding preserved; confined to Walloomsac bedrock channel.



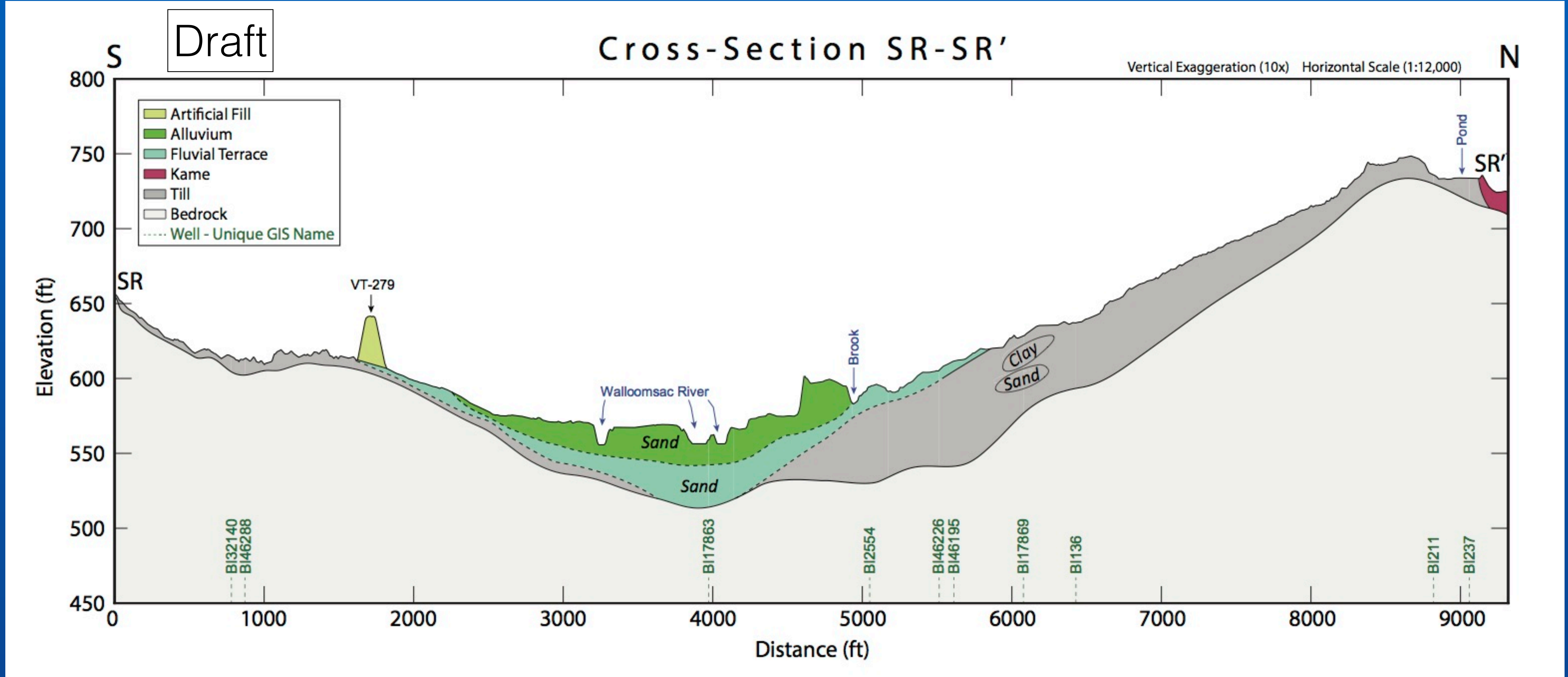
Unit 1 Walloomsac basal alluvium; basal cobble to pebble gravel with silt & small wood fragment; fines upward through medium sand to fine sand & silt; disseminated organic matter throughout.

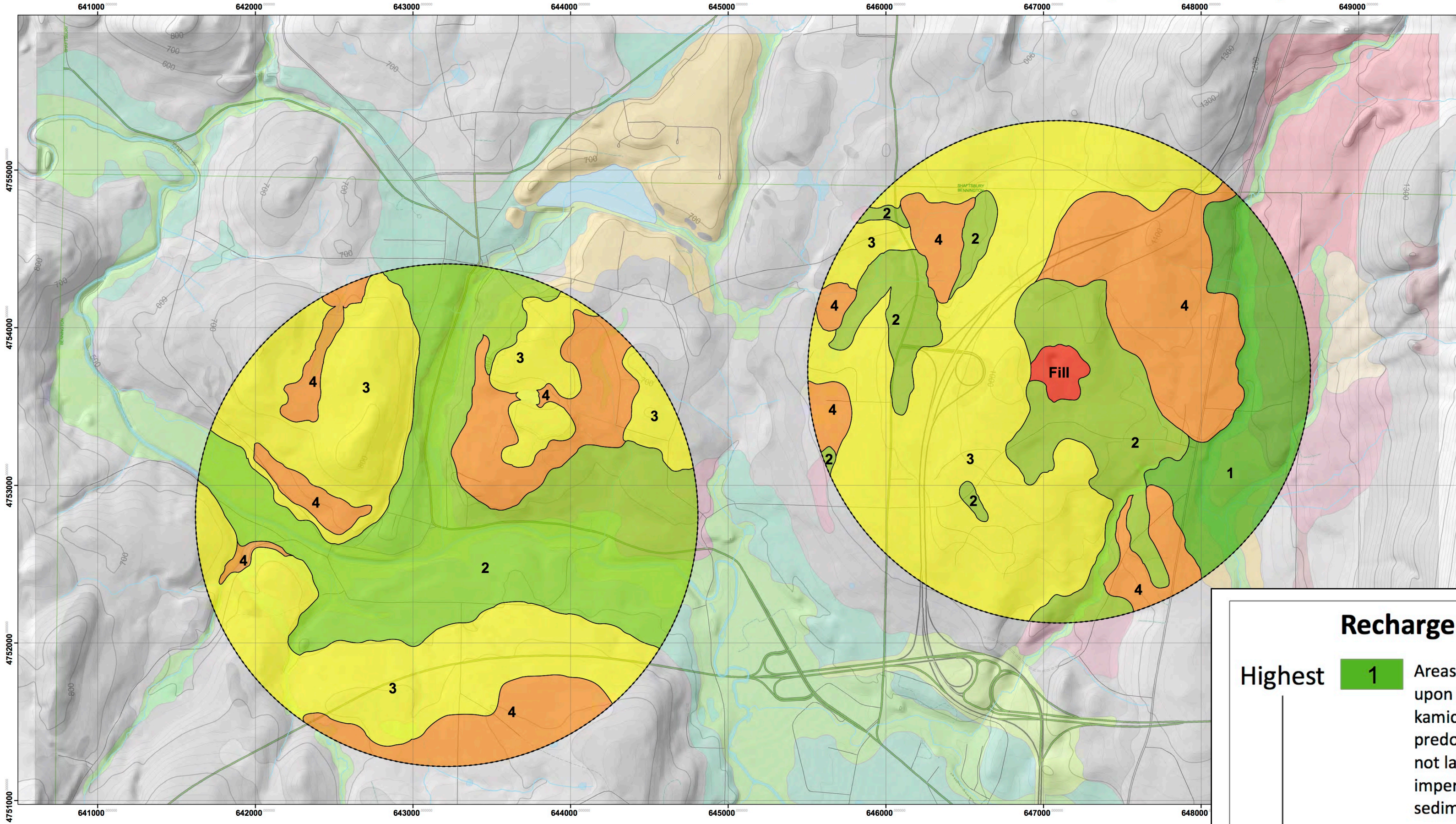


Bedrock Whitish-weathering, gray crystalline dolomitic limestone of the Shelburne Formation

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Walloomsac Valley section also reveals 2 sandy terrace sequences that may correlate to Units 1 & 2 in the ChemFab fence diagram.





Aquifer Recharge Potential

> Paran Creek alluvium does not inhibit downward flow of contaminants to bedrock aquifer.

Recharge Potential

- Highest
- 1 Areas of highly permeable overburden that are believed to be comparatively thick and persistent based upon well logs and the character of the deposits. The extensive kame moraine and outwash with adjacent kamic areas have the highest potential to recharge the bedrock aquifer. A kame moraine consists of predominantly fluvial sediment that may have lenses and interbeds of low permeability till that are typically not laterally extensive. Outwash is a highly permeable fluvial deposit of gravel and sand with little or no impermeable sediment. Adjacent kamic deposits may have both permeable and impermeable interbedded sediments.
- 2 Areas of intermediately permeable materials including kamic sediment, outwash, moraine, eroded till, fluvial terraces and alluvium. The kamic areas are likely the most permeable sediment of this category and consist largely of gravel and sand. The area of outwash included in this group has an unknown thickness and may overlie bedrock or till. The small morainal feature is not well expressed and may be more kame moraine in sediment texture. Eroded till punctuated by several bedrock exposures suggests comparatively easy recharge to the bedrock aquifer. Fluvial terraces and alluvium consist of gravel, sand and silt in variable proportions with highly variable surface layer permeability.
- 3 Areas of thin till overlying bedrock. The upper meter or so of the till is typically weathered to a more permeable texture than the underlying till. Weathered till should allow water infiltration to bedrock more easily than unweathered till. The process of soil formation oxidizes and alters the upper meter or so of the sediment and thinner areas of till may be weathered throughout the sediment profile. In addition, this group includes small rock outcrops within areas of till.
- Lowest
- 4 Areas of thick impermeable till. Thick till has a thicker profile of unweathered till beneath the soil zone than weathered till. Unweathered till has an extremely low permeability and low recharge potential. A small area of exposed glacial lake clay-silt is also assigned to this category as clay-silt has a very low permeability.

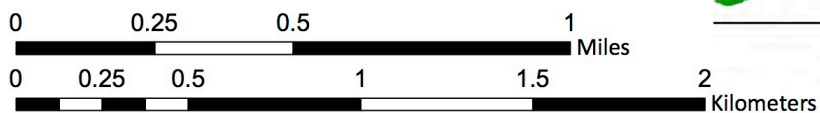
Aquifer Recharge Potential as a F of Surficial Materials North Benning

Vermont Geological Survey Open File Report VG

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Scale 1:12,000
Contour Interval = 20 ft

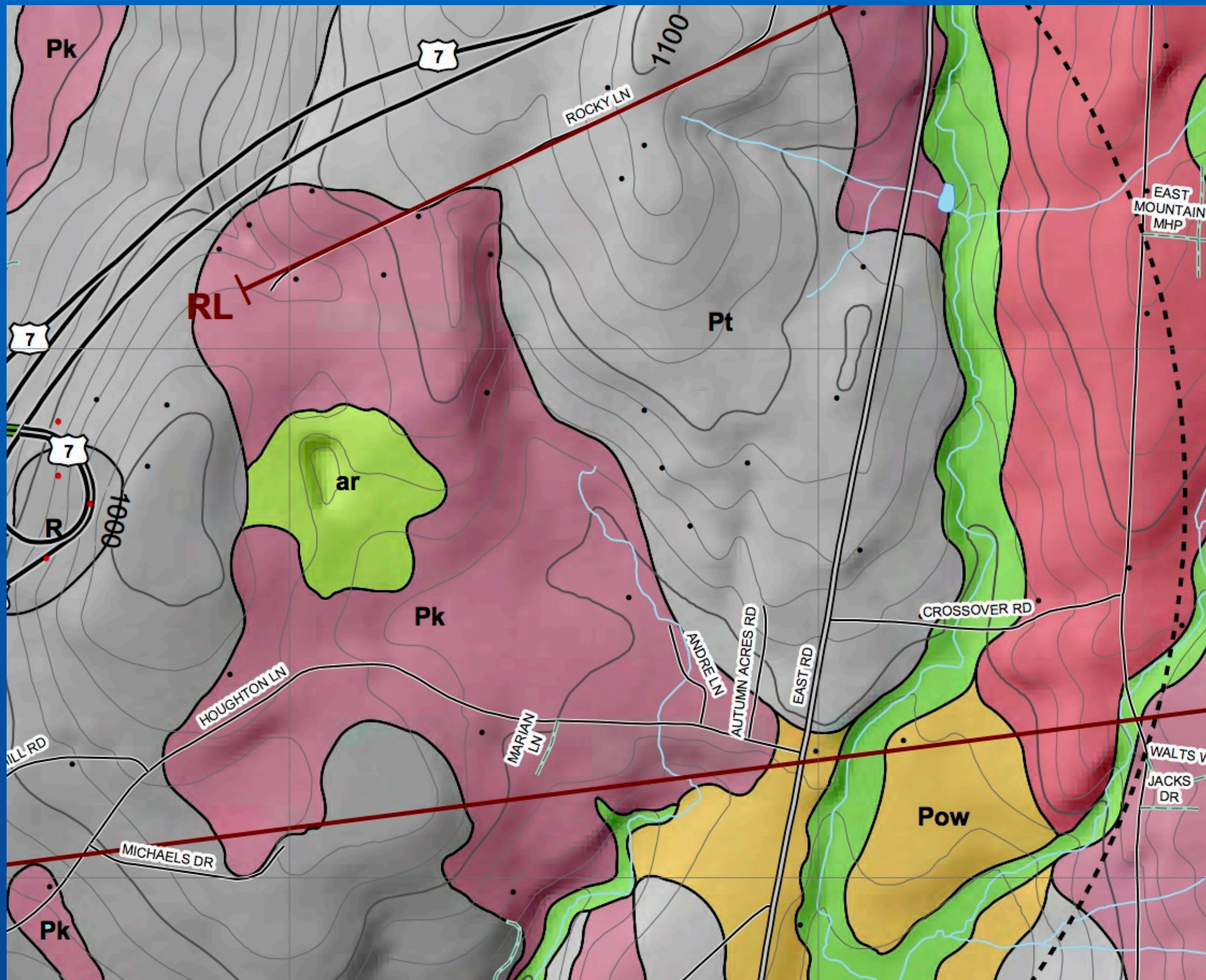


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Recharge Potential

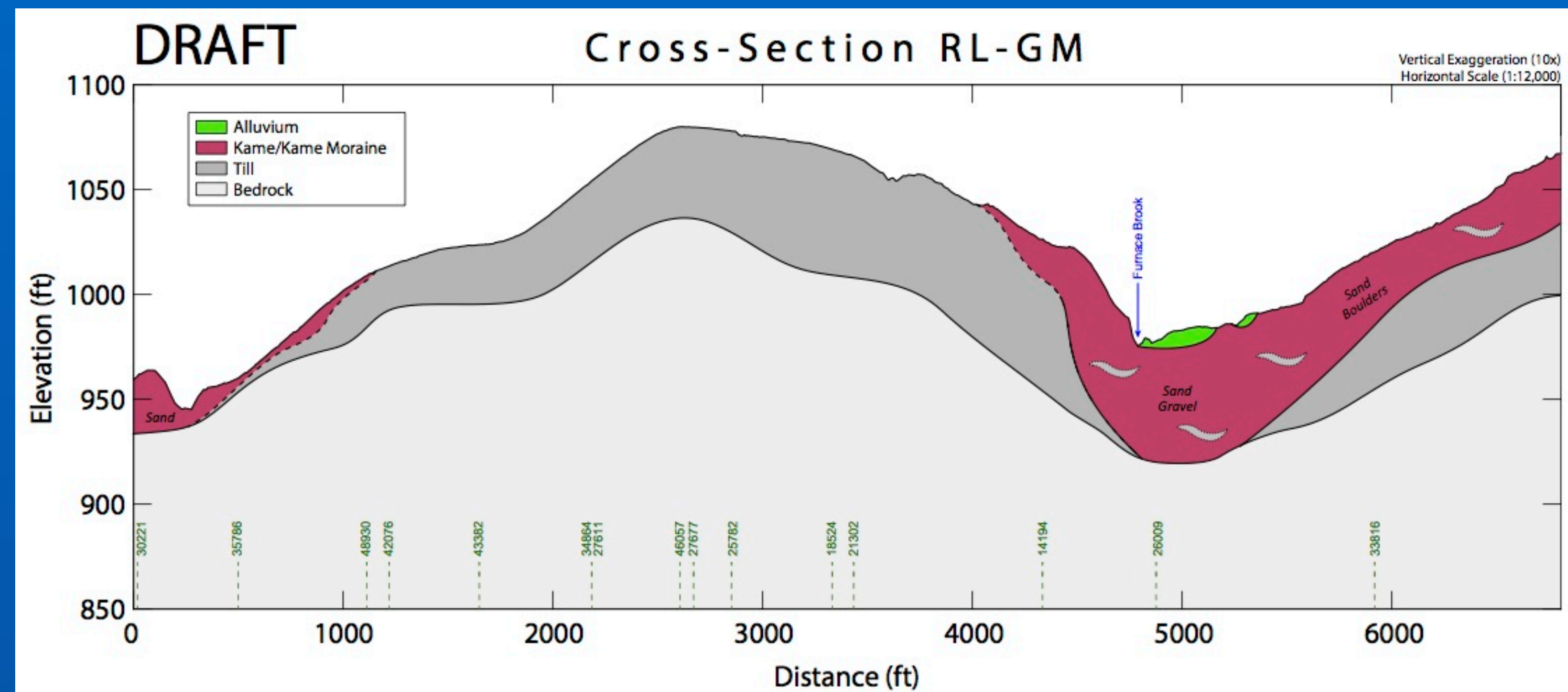
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Old Landfill Detail

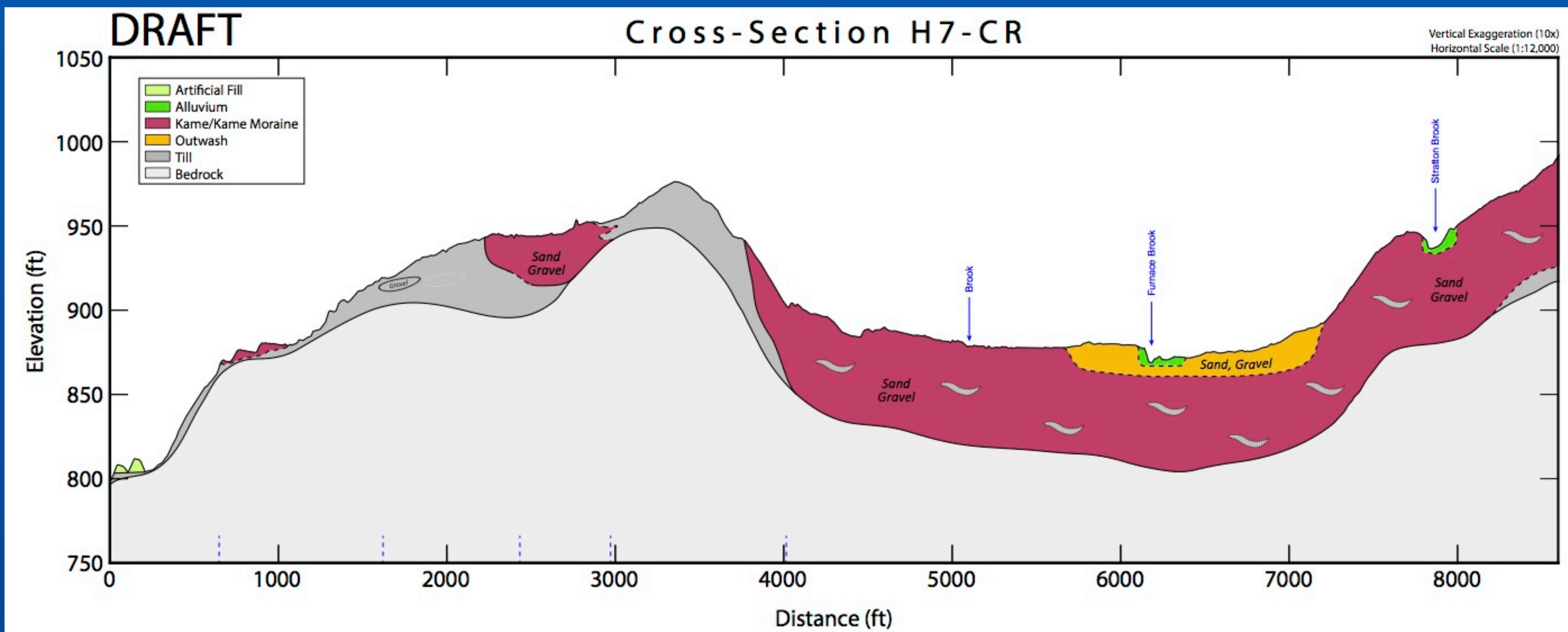
- > Ice margin on NW side of ridge
- > Stagnant ice to lee of ridge
- > Typical landfill from half a century ago



Two Cross Sections

> North & south of Old Landfill

> Thick sand & gravel



> Easy infiltration of PFOA into the subsurface

> Probable valuable overburden aquifer

Conclusions

> Role of the surficial/Quaternary geologist in these investigations - geomorphology matters

- * Interpret landscape evolution
- * Interpret overburden stratigraphy
- * 3-D distribution of sediments and their textures must fit the interpretation of landscape development
- * Generate aquifer recharge maps for infiltration to either/both overburden and bedrock aquifers
- * Identify possible pathways of waste migration
- * Wind deposition of airborne contaminants & pattern of contaminated wells may be better understood if permeability of overburden is evaluated

> Synergy of having both surficial and bedrock expertise involved is invaluable

- * We help each other...bounce ideas...even off the wall ones
- * Modelers of bedrock aquifer flow must consider recharge through overburden