Evaluation of Groundwater Resources in the Town of Craftsbury, Northeastern Vermont Using Bedrock, Surficial, and Topographic Maps

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Abstract

The Town of Craftsbury straddles the Richardson Memorial Contact (RMC)- a regional lithotectonic boundary that separates metamorphic rocks of the Green Mountain Belt (GMB) to the west from those of the Connecticut Valley Belt (CVB) to the east. The RMC is a Silurian unconformity that is locally coincident with a Devonian fault(s). The GMB is composed of pre-Silurian phyllites and phyllitic quartzites of the Moretown and Cram Hill fms. whereas Silurian-Devonian siliceous marbles, phyllites and isolated granites comprise the CVB.

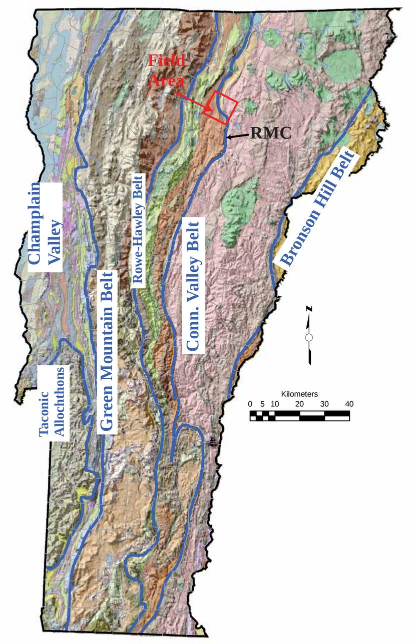
The marble-rich lithologies directly to the east of the RMC have been eroded to form a broad depression in which the Black River and a number of elongate N-S lakes are found. Uplands composed of pre-Silurian and Silurian-Devonian metamorphic rocks are located to the west and east, respectively, of the Black River Valley lowlands.

Uplands are primarily underlain by dense silt- and fine-sand-matrix glacial till. Till is thin (<20') on hilltops and bedrock outcrops are abundant. Striations and grooves indicate ice motion of ~170-195°. Scattered ice-contact sand and gravel deposits overlie till in places. Glaciolacustrine deposits are common below ~1120'. Probable delta deposits are found at ~1120'.

There are 221 accurately located groundwater wells in Craftsbury and 100% (n=221) were completed in bedrock. Wells in Silurian-Devonian bedrock have slightly higher average yields and total depths (13 gpm; 267') than those in pre-Silurian bedrock (10 gpm; 259'). Surficial wells (n=13) have average yields of 40 gpm. Preliminary analysis suggests that the elevated yields of some bedrock wells may be related to the presence of thick, saturated, and porous surficial deposits that overlie the bedrock.

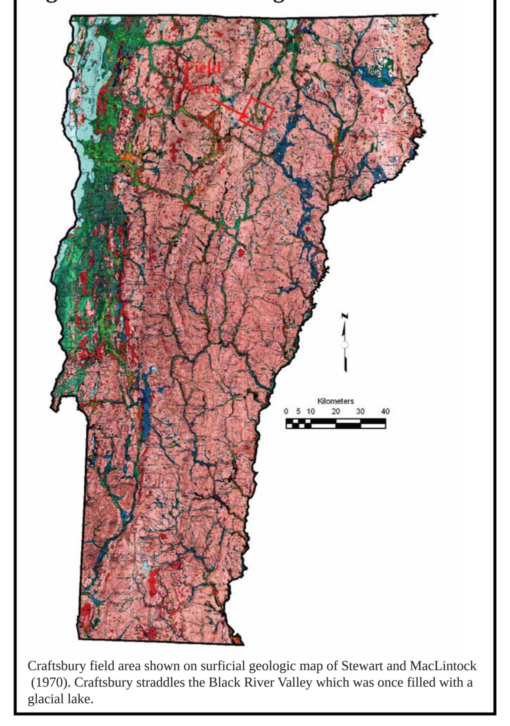
Further analysis seeks to correlate well yields with other factors such as fracture domains, topographic slope, proximity to water bodies or lineaments, and drainage area(s).

Figure 1- Bedrock Geologic Context



Craftsbury field area shown on bedrock geologic map of Doll (1961) with overlay of lithotectonic belts.

Figure 2- Surficial Geologic Context



Craftsbury field area shown on surficial geologic map of Stewart and MacLintock (1970). Craftsbury straddles the Black River Valley which was once filled with a glacial lake.

Figure 3- Bedrock Geologic Map for the Town of Craftsbury (Kim et al., 2010)

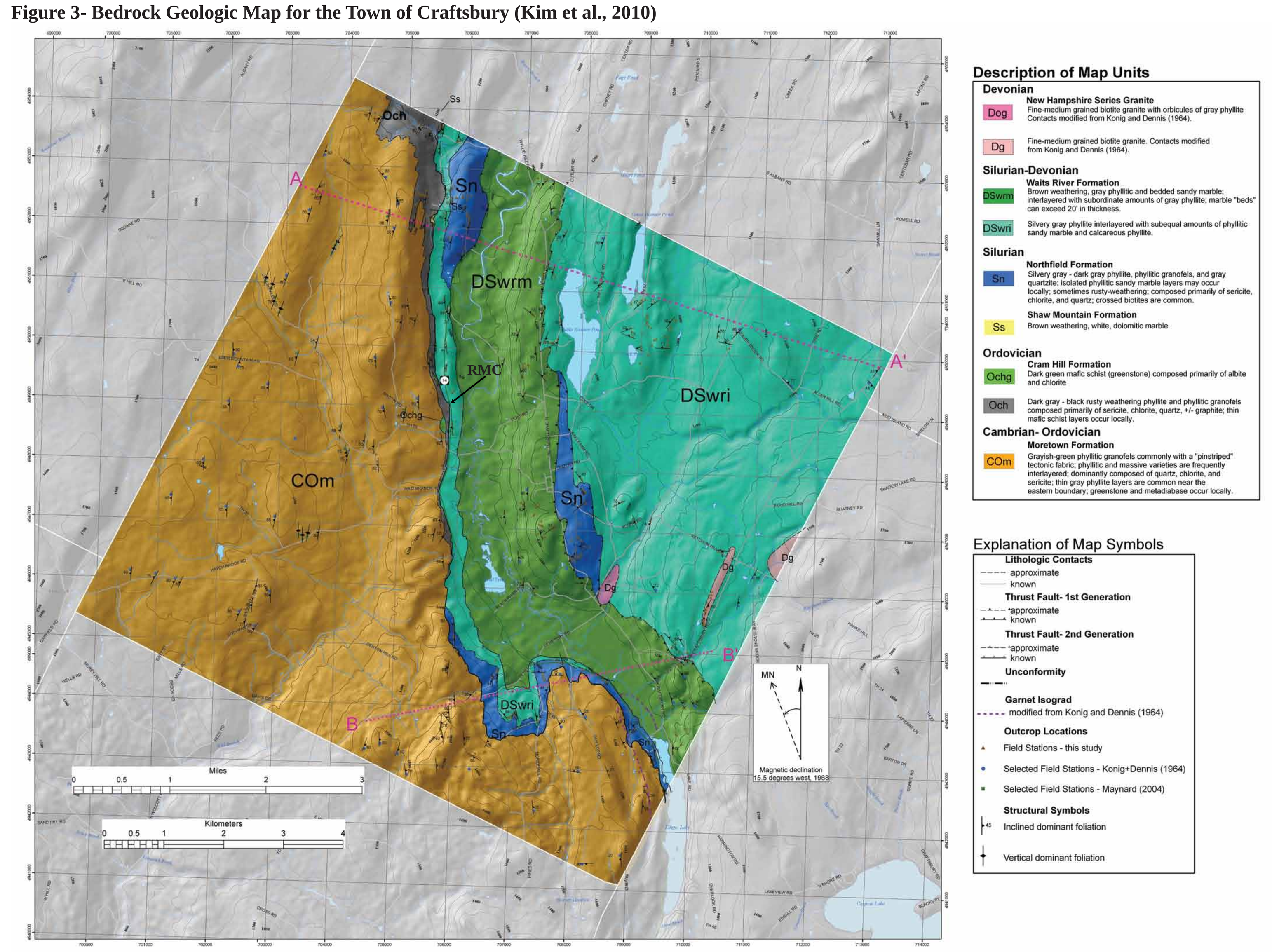


Figure 4- Surficial Geologic Map for the Town of Craftsbury (Springston and Maynard, 2010)

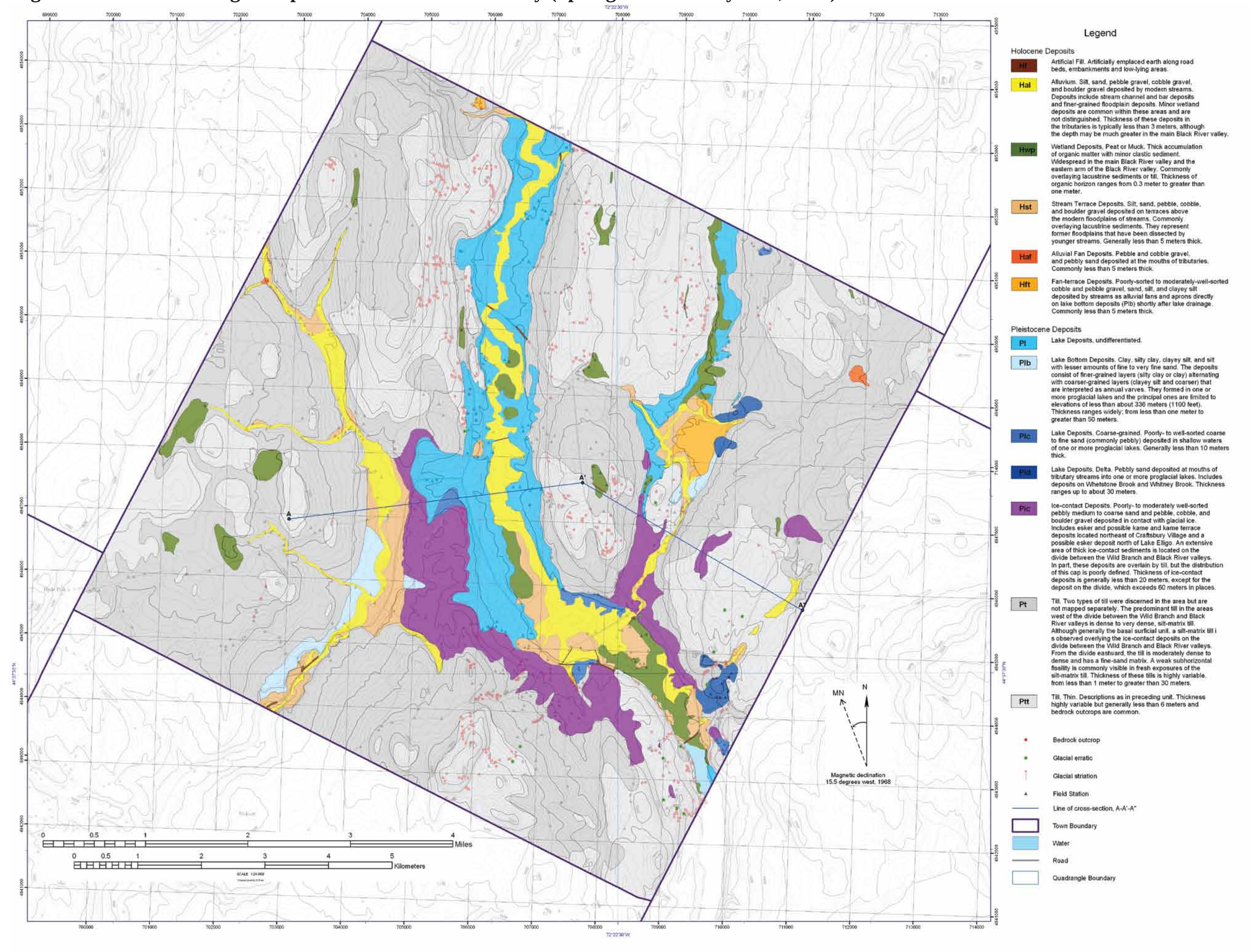


Figure 5A- Bedrock Cross Sections

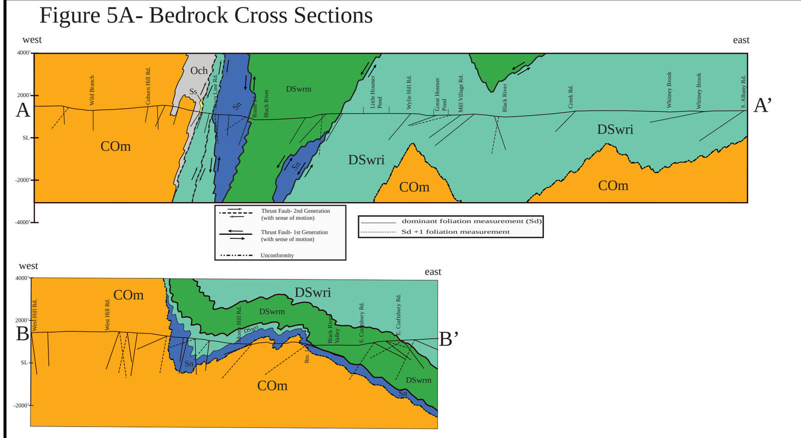
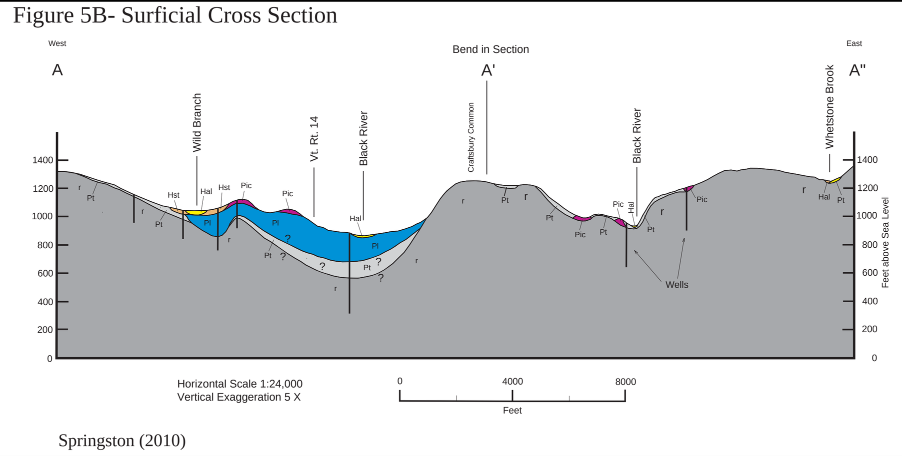
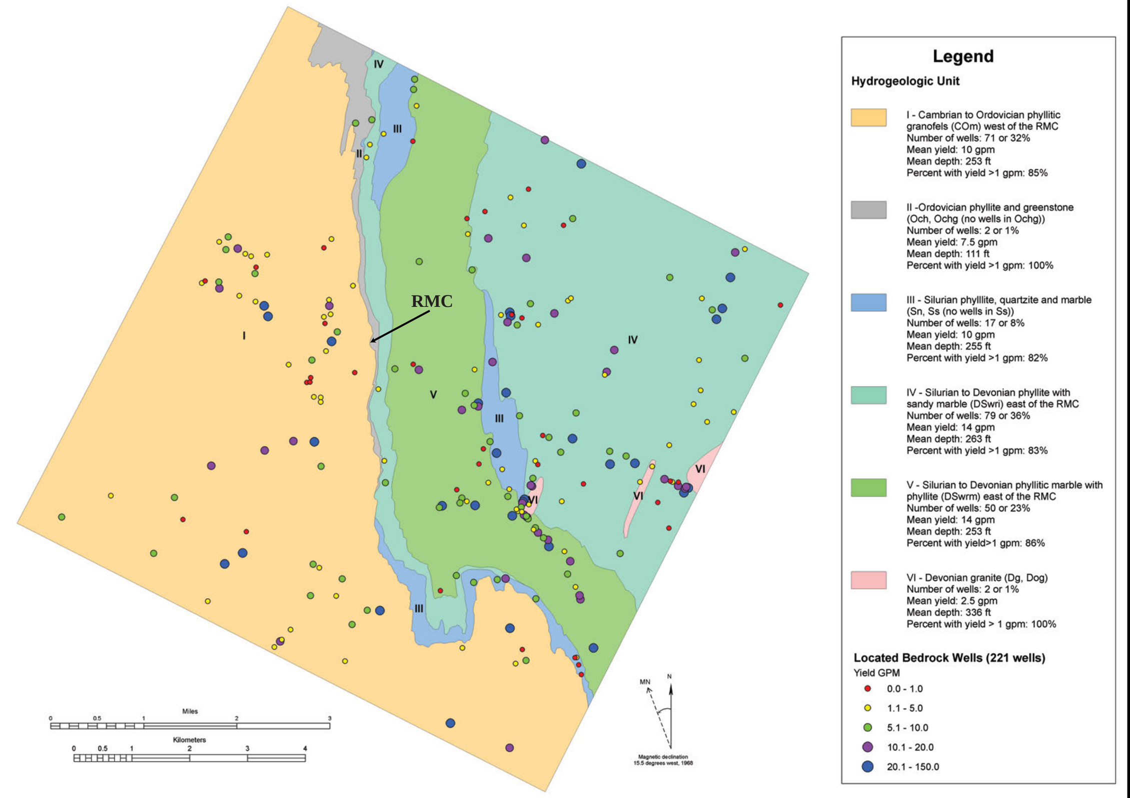


Figure 5B- Surficial Cross Section



Springston (2010)

Figure 6- Bedrock Hydrogeologic Units



For this map, bedrock hydrogeologic units basically correspond with formations. The yields of accurately located (GPS, E-911) bedrock wells are shown as scaled and colored circles (n=221). Mean yields, wells depths, and % of wells with yields > 1 gpm are shown for each unit in the legend. Figure 7A shows a bar graph of yields by bedrock hydrogeologic unts.

Figure 7A- Mean Yield (GPM)/Bedrock Hydrogeologic Unit

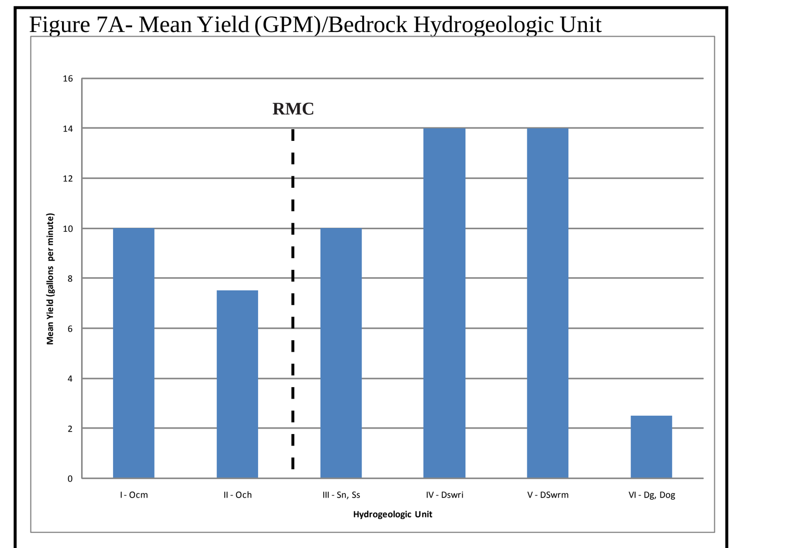
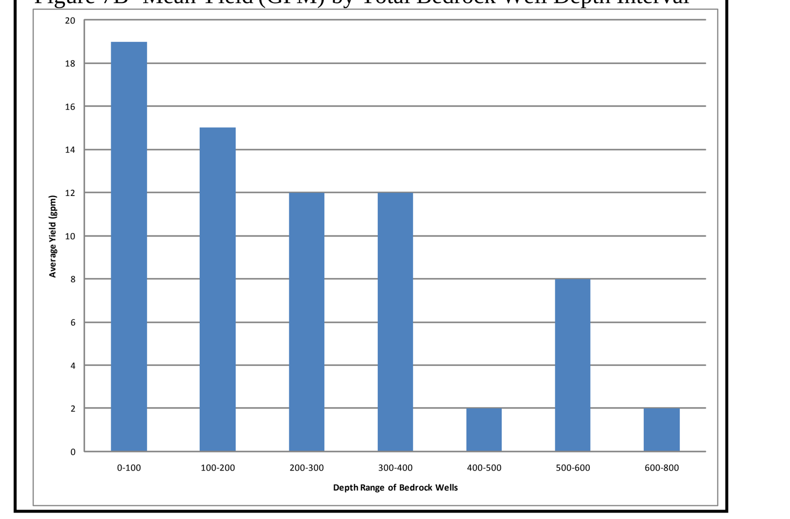
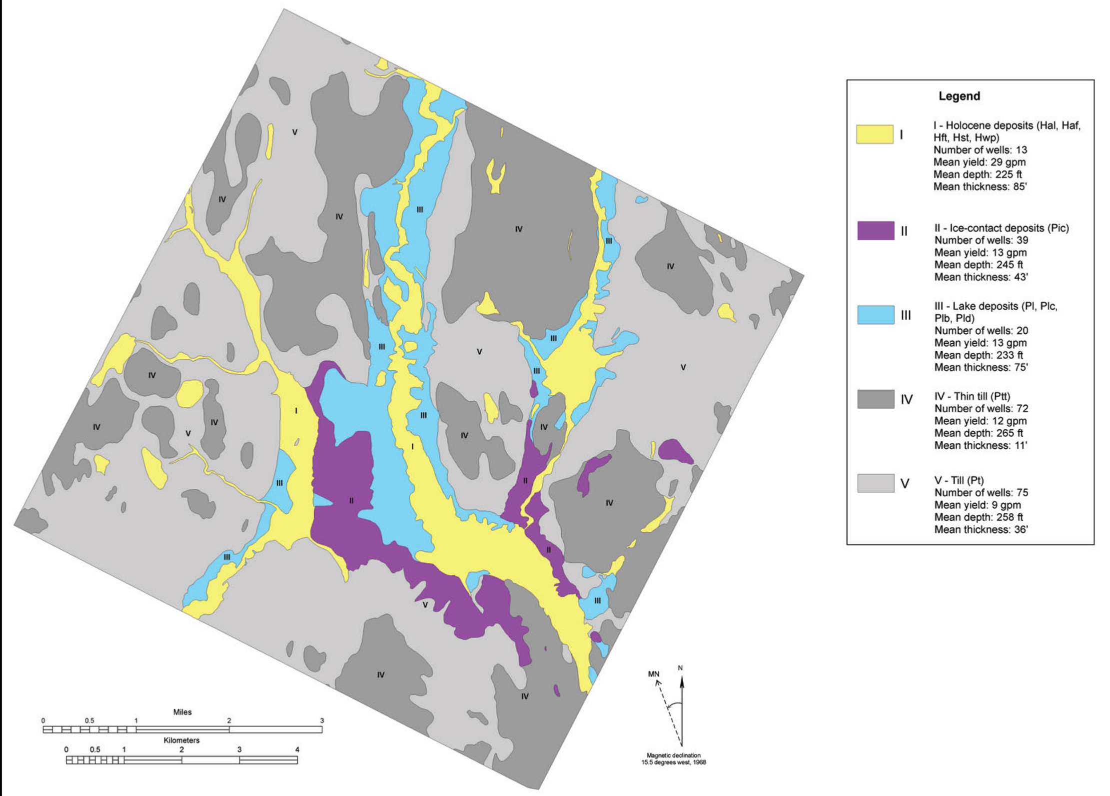


Figure 7B- Mean Yield (GPM) by Total Bedrock Well Depth Interval



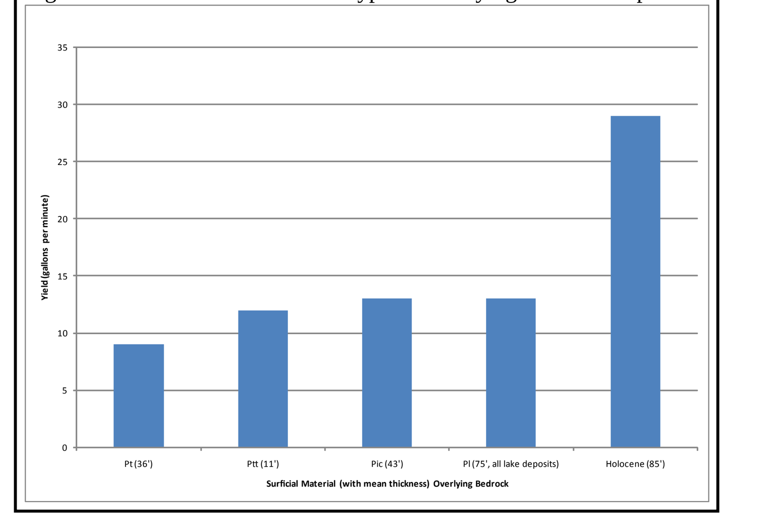
Bar graph that shows how the average yield of Craftsbury bedrock wells decrease as total depths increase.

Figure 8- Surficial Hydrogeologic Units

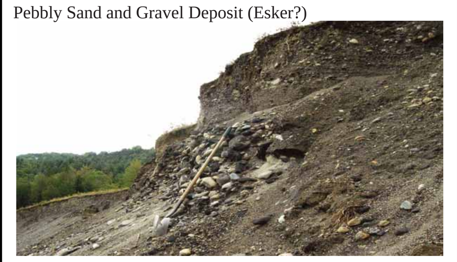


Surficial hydrogeologic units represent deposits of similar age and sedimentologic character that were lumped together. We were interested in whether the surficial hydrogeologic units themselves or their thicknesses influenced the yields of bedrock wells. Figure 9 shows that the mean yields for bedrock wells completed through each surficial hydrogeologic unit are similar, with those completed below the Holocene units having the highest mean yield.

Figure 9- Bedrock Well Yield vs. Type of Overlying Surficial Deposit



Pebbly Sand and Gravel Deposit (Esker?)



Bedrock spring in the Waits River Formation

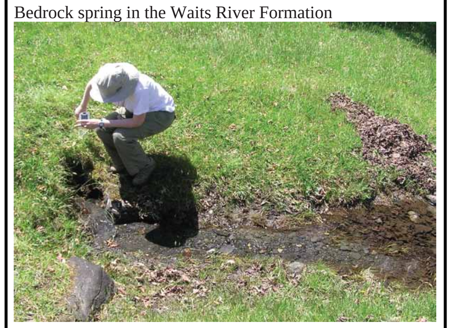
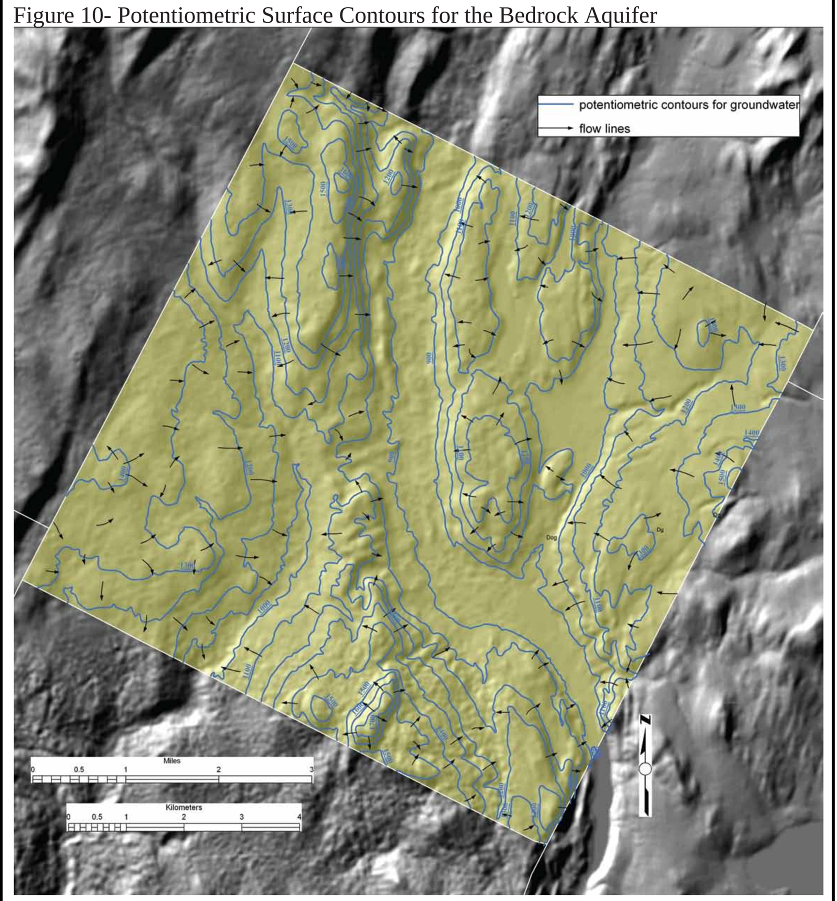


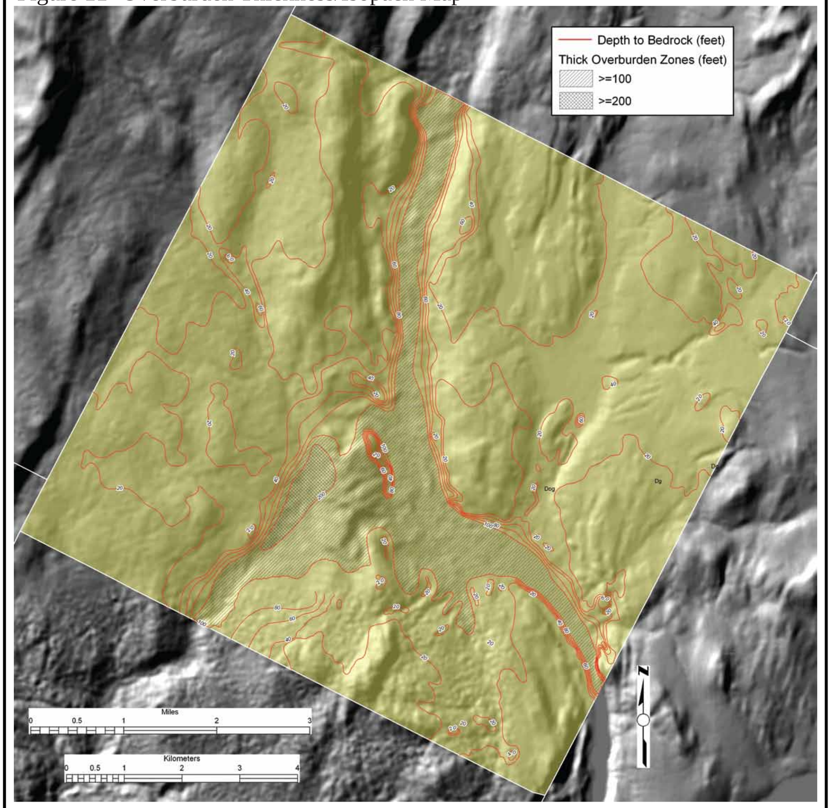
Figure 10- Potentiometric Surface Contours for the Bedrock Aquifer



Generalized potentiometric surface contours for groundwater in the bedrock aquifer constructed from static water levels (SWL) derived from domestic bedrock well logs and topographic maps. Because of data gaps (only 25% of these wells reported SWLs) , these contours are only approximations. The flow lines reveal general directions, not specific pathways, of groundwater flow and show recharge from higher regions in an aquifer to regions of discharge in lower portions of an aquifer. Flow lines commonly follow the topography.

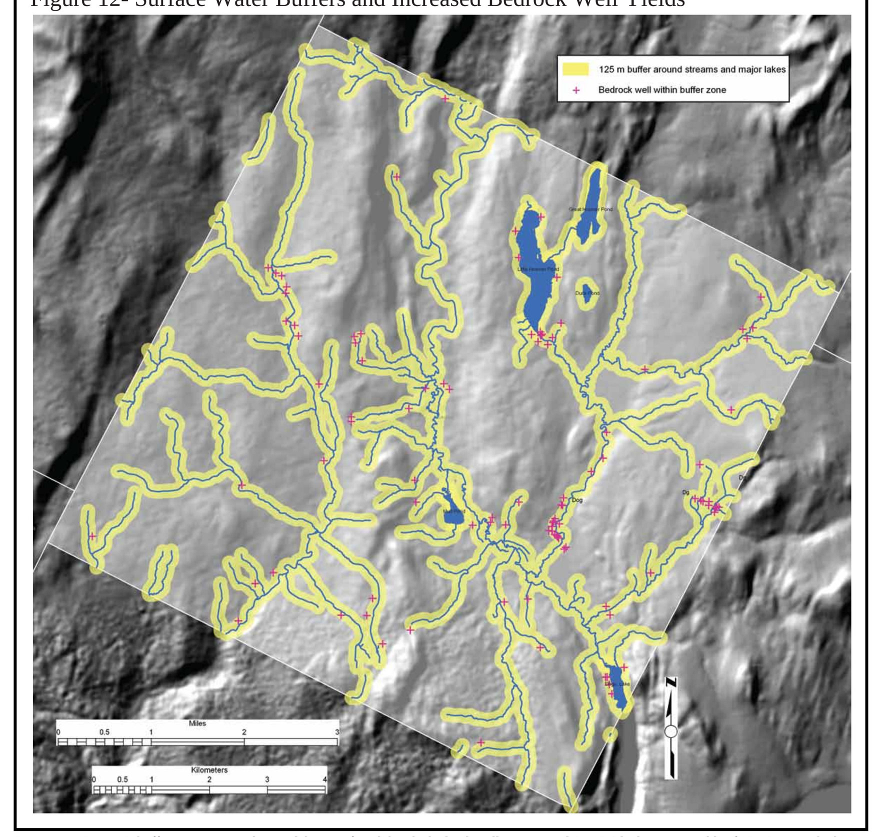
Determining bedrock depth using seismic refraction

Figure 11- Overburden Thickness/Isopach Map



This isopach map was constructed using overburden depths from domestic well logs in conjunction with topographic maps and DEMs. The greatest overburden depths are found in the Black River Valley and in a southwest trending bedrock channel.

Figure 12- Surface Water Buffers and Increased Bedrock Well Yields



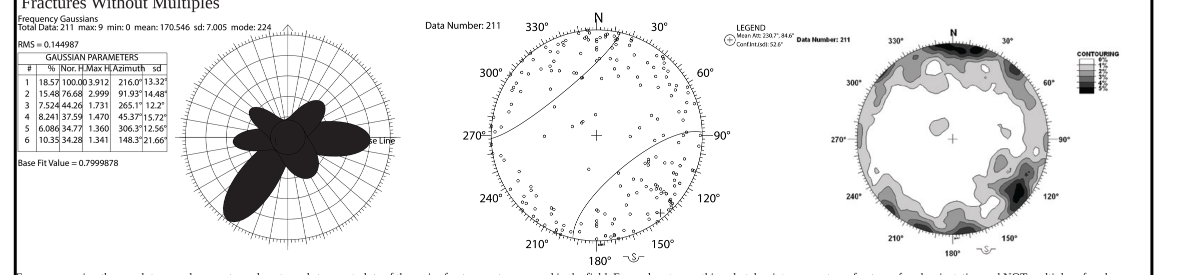
By using 125 m/ 410' buffer on streams and major lakes, we found that the bedrock wells intercepted (n=104) had average yields of 17-18 gpm, which was significantly higher than the yields reported for any individual rock formation. This increase could be due to the concentration of groundwater flow towards streams and lakes, to water loss from streams and lakes, or to a combination of the two.

Figure 13- Preliminary Fracture Analysis

The most common type of fracture in the field area was orthogonal to bedding and foliation like shown above. These fractures trend nearly E-W with large error bars.

Other fractures formed as a brittle cleavage that was axial planar to Devonian folds. These fractures trend NE-SW with large error bars.

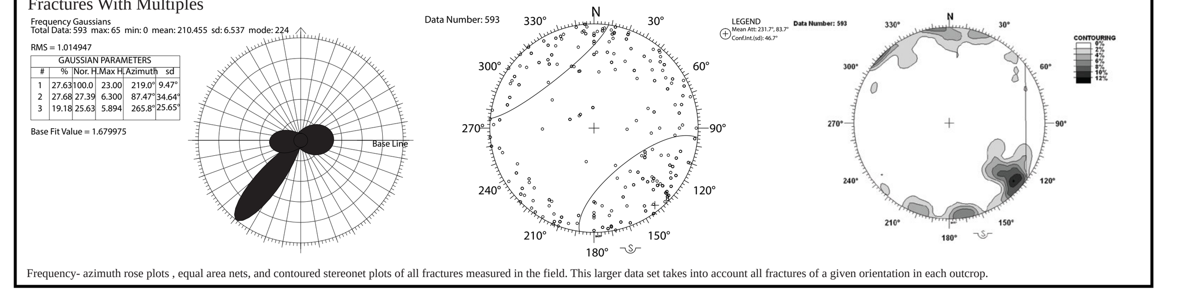
Fractures Without Multiples



#	%	Nor. H.	Max H.	Azimuth	sd
1	18.57	100.00	3.912	216.0°	13.32°
2	15.48	76.68	2.999	91.93°	14.48°
3	7.524	44.26	1.731	265.1°	12.2°
4	8.241	37.59	1.470	45.37°	15.72°
5	6.086	34.77	1.360	306.3°	12.56°
6	10.35	34.28	1.341	148.3°	21.66°

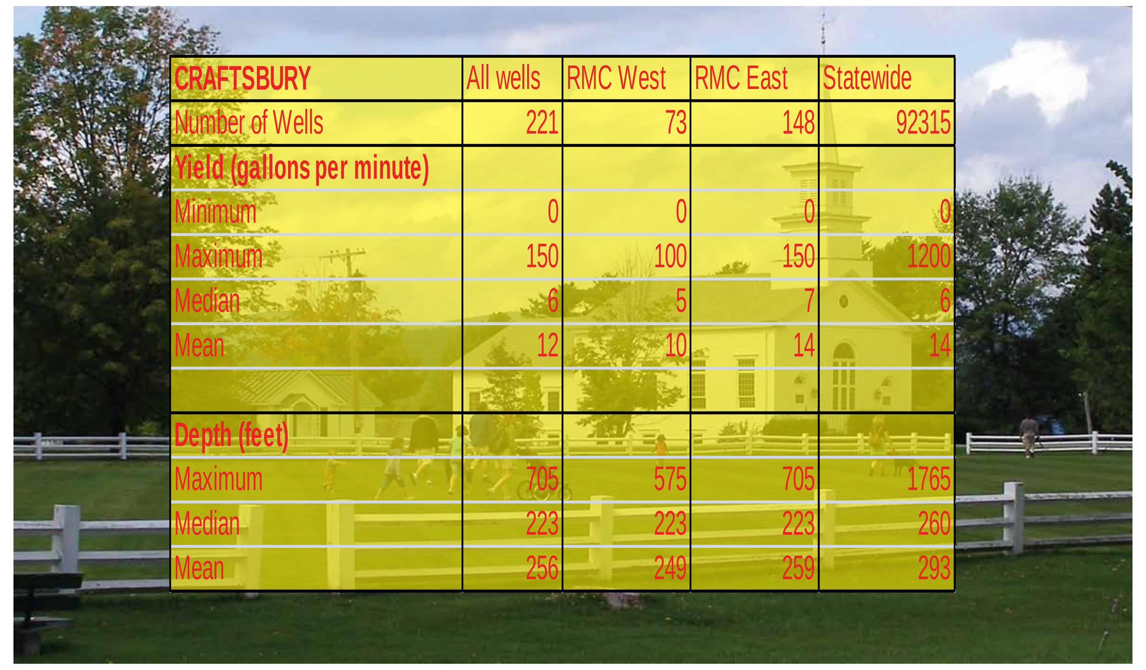
Frequency- azimuth rose plots , equal area nets, and contoured stereonet plots of the major fractures sets measured in the field. For each outcrop, this only takes into account one fracture of each orientation and NOT multiples of each.

Fractures With Multiples



#	%	Nor. H.	Max H.	Azimuth	sd
1	27.63	100.0	23.00	219.0°	9.47°
2	27.68	27.39	6.300	87.47°	34.64°
3	19.18	25.63	5.894	265.8°	25.65°

Frequency- azimuth rose plots , equal area nets, and contoured stereonet plots of all fractures measured in the field. This larger data set takes into account all fractures of a given orientation in each outcrop.



CRAFTSBURY	All wells	RMC West	RMC East	Statewide
Number of Wells	221	73	148	92315
Yield (gallons per minute)				
Minimum	0	0	0	0
Maximum	150	100	150	1200
Median	6	5	7	6
Mean	12	10	14	14
Depth (feet)				
Maximum	705	575	705	1765
Median	223	223	223	260
Mean	256	249	259	293