GROUNDWATER RESOURCES IN THE TOWN OF WILLISTON, NORTHWEST VERMONT

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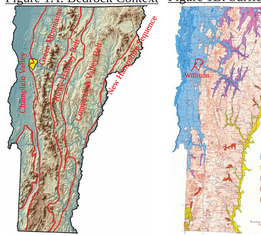
ABSTRACT

Bedrock and surficial geologic maps of Williston serve as an integrated framework for addressing groundwater quantity and quality (radionuclide) issues. The town is underlain by metamorphosed Late Proterozoic-Cambrian rift to drift stage clastic rocks of the Green Mountains structurally overlying Lower Cambrian- Middle Ordovician carbonate and clastic continental shelf rocks of the Champlain Valley. These sections were juxtaposed along the west-directed Hinesburg Thrust (HBT) during the Taconian Orogeny. Pleistocene- Holocene surficial deposits overlie this bedrock. Gently sloping terraces underlain variably by sand, silt-clay or deformed till protrude through rounded hills in the north part of town and step down to the Winooski River. Terraces were coeval with Fort Ann Upper, Fort Ann Lower and Champlain Sea levels. The south consists of structurally controlled stream valleys draining glacially scoured hills and ridges. Bedrock lithologies and structures and glacial deposits strongly influence the hydrogeology.

Recently drilled domestic wells indicate that the HBT is a high-yielding structural aquifer with yields averaging ~50 GPM. In the southern part of town, the Lake Iroquois Thrust (LIT) is east of the HBT, but these faults merge together to the north. Fractures in the upper plate of the combined HBT and LIT are dominantly E-W trending whereas lower plate fractures trend more NW. Localized elongate topographic basins in the bedrock formed along the leading edge of the HBT and LIT and also along E-W and NW-SE fracture zones and were filled with thicker surficial deposits; higher yielding wells in these basins may locally benefit from thick permeable overburden. A prominent E-W fracture set controlled the preglacial development of Old Creamery and Butternut tributary valleys. Both valleys were in-filled with a wedge of till and Old Creamery also accumulated considerable melt water sediment. Allen Brook flows north and follows prominent ductile structures, but also likely excavated a preglacial valley just east of the trace of the LIT. Several producing gravel wells confirm the presence of a minor aquifer in the bottom of the bedrock trough beneath thick till. We also hypothesize a possible northward and/or eastward extension of this Allen Brook trough; this would represent an overburden aquifer prospect.

Figure 1A: Bedrock Context



Town of Williston (yellow) shown on bedrock lithotectonic map of Vermont. The Hinesburg Thrust runs through Williston.

Figure 1B: Surficial Context

Town of Williston (unshaded red polygon) shown on Glacial and Post-Glacial Lakes map of Vermont (modified from Stewart and MacClintock1970).

Figure 2: Bedrock Geologic Map

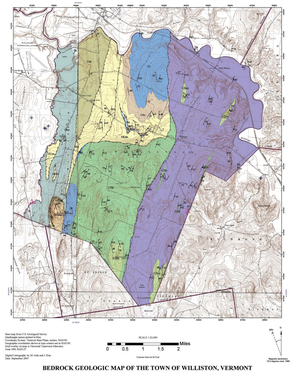


Figure 3A: Surficial Geologic Map

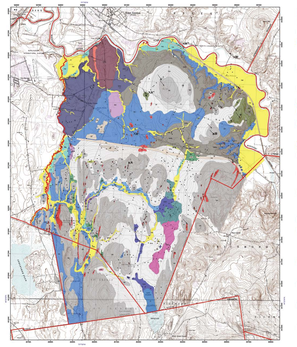
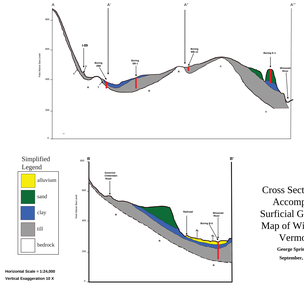


Figure 3B: Surficial Cross-Sections



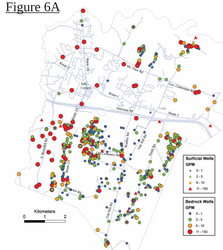
Cross Sections to Accompany Surficial Geologic Map of Williston, Vermont

George Springston

September, 2007

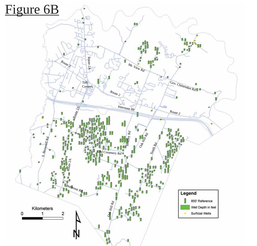
Basic Data Derived from Wells

Figure 6A



Well yields for bedrock and surficial wells in gallons/ minute (GPM). The locations of these wells were verified through correlation with E911 addresses and other town data.

Figure 6B



Total depths (in feet) for wells in Williston. Surficial (gravel) wells are indicated with yellow halos.

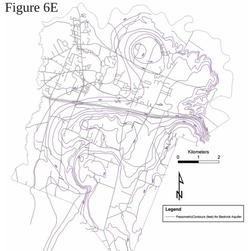
Figure 6C

"Specific Capacity" of wells (see definition in map legend). Surficial (gravel) wells shown with yellow halos.

Figure 6D

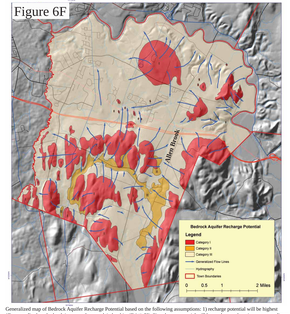
Isopach map showing overburden depths/ depths to bedrock in feet. Note locations of basins with thick surficial deposits

Figure 6E



Piezometric contours (in feet)-derived from static water levels in bedrock wells.

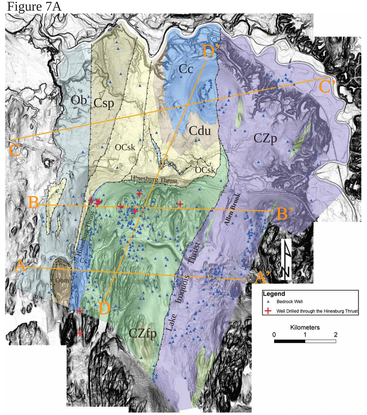
Figure 6F



Generalized map of Bedrock Aquifer Recharge Potential based on the following assumptions: 1) recharge potential will be highest (Category I) where bedrock is exposed or overlain by thin till (<=3'); 2) recharge potential will be moderate where ice contact sediment is wholly or partially in contact with bedrock (Category II); 3) recharge potential will be lowest in areas where overburden is relatively impermeable (Category III) i.e. thick till, some alluvium, clay). Generalized flow lines were drawn based on the piezometric contours.

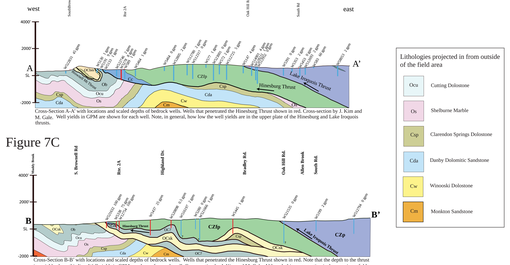
The Hinesburg Thrust Story

Figure 7A



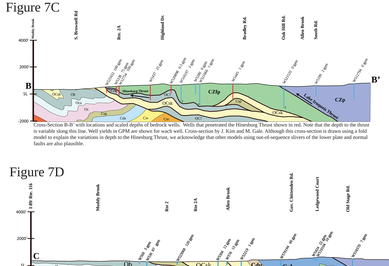
Bedrock geology, cross-section locations, bedrock well locations, and wells that penetrated the Hinesburg Thrust overlayed on slope map generated from LIDAR data. Well logs and discussions with well drillers were used to identify bedrock wells that penetrated the Hinesburg Thrust; these wells have yields that average ~50 gpm. Well depths were used to constrain all cross-sections below.

Figure 7B



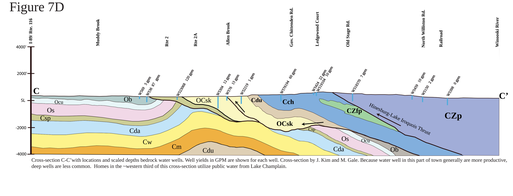
Cross-Section A-A' with locations and scaled depths of bedrock wells. Wells that penetrated the Hinesburg Thrust shown in red. Cross-section by J. Kim and M. Gale. Well yields in GPM are shown for each well. Note, in general, how low the well yields are in the upper plate of the Hinesburg and Lake Iroquois threats.

Figure 7C



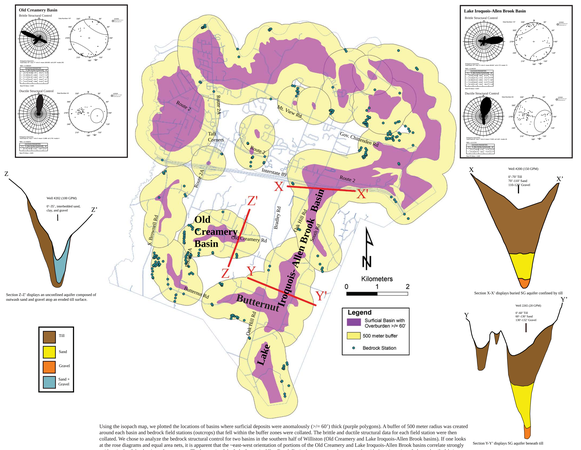
Cross-Section B-B' with locations and scaled depths of bedrock wells. Wells that penetrated the Hinesburg Thrust shown in red. Note that the depth to the thrust is variable along this line. Well yields in GPM are shown for each well. Cross-section by J. Kim and M. Gale. Although this cross-section is drawn using a fold model to explain the variations in depth to the Hinesburg Thrust, we acknowledge that other models using out-of-sequence slivers of the lower plate and normal faults are also plausible.

Figure 7D



Cross-section C-C' with locations and scaled depths bedrock water wells. Well yields in GPM are shown for each well. Cross-section by J. Kim and M. Gale. Because water well in this part of town generally are more productive, deep wells are less common. Homes in the ~western third of this cross-section utilize public water from Lake Champlain.

Figure 8



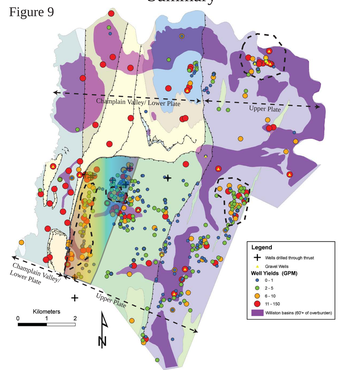
Integration of Bedrock and Surficial Geology

Using the isopach map, we plotted the locations of basins where surficial deposits were anomalously (>= 60') thick (purple polygons). A buffer of 500 meter radius was created around each basin and bedrock field stations (outcrops) that fell within the buffer zones were collated. The kettle and dactile structural data for each field station were then collated. We chose to analyze the bedrock structural control for two basins in the southern half of Williston (Old Creamery and Lake Iroquois-Allen Brook basins). If one looks at the structural data from the bedrock stations in the vicinity of the Old Creamery Basin, there is a prominent E-W fracture set. Bedrock stations in the Lake Iroquois-Allen Brook Basin are generally with attitude of the dominant fracture sets. The long axis of the Lake Iroquois-Allen Brook Basin, however, correlates strongly with the orientation of planar ductile fabrics.

Simplified surficial cross-sections were constructed across the Old Creamery(1) and Lake Iroquois(2) basins by D. DeSimone in the immediate vicinity of high-yielding wells. All these cross-sections show that porous and permeable sands and gravels underlie till in these basins. There are also high-yielding bedrock wells in the Old Creamery Basin that have thick surficial deposits overlying bedrock; recharge to these wells likely occurs from above when these deposits are permeable to the surface, however recharge has to be from below when impermeable layers of till overlie the permeable sands and gravels.

Summary

Figure 9



Generally high yields (avg = 48 GPM) are associated with wells (n=9) that penetrate the Hinesburg Thrust. Preliminary structural analysis suggests that the probability of penetrating the thrust at shallower depths (<1000') increases to the west (within rainbow pattern in above figure).

-Some bedrock-controlled basins have thick surficial deposits (>/= 60') with permeable sands and gravels at the bottom that are hosts for productive surficial wells (i.e. Old Creamery and Lake Iroquois); productive bedrock wells are also found in some of these basins.

- Wells drilled in the rocks of the lower plate of the Hinesburg Thrust/Champlain Valley (see above) are much more productive (average yield = 28 GPM; median yield = 13 GPM) than those in the upper plate (average yield = 8 GPM; median yield = 2 GPM). Very low yielding bedrock well groupings are found in parts of this upper plate.

-Some groupings of high-yielding wells in the upper plate of the Hinesburg Thrust that do not penetrate the thrust are found in northeast, east-central, and west-central Williston (see dashed polygons) and are currently under investigation.