Analysis of Groundwater Resources in the Town of East Montpelier, Central Vermont

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Abstract

In the summer of the Last Hampshire Solici Board, the Vermont Geological Survey (VGS) and the Norwich University Department of Geology (NU) began a cooperative study of the surficial geology and groundwater resources of the Town of East Montpelier. The study focuses on the continuous Town East Montpelier aquifer as well as nearby bedrock aquifers, which is since using GPS units. These wells were large bedrock wells (wells that have independently constructed wells) and 25 locations (of 32 total wells). Each well was located and a water level measurement was taken. Water levels were used to create a map of the potentiometric surface of the aquifer. This map will be used to integrate the well log data with the geologic maps in order to produce derivative maps that bear directly on groundwater resources. We have produced surficial and surficial maps, highlight findings of the derivative maps, and then compile data related to the Antonovich spring(s).

The Rochdalean Metamorphic Complex (RMC), which is a faulted Silurian unconformity that runs through the northwestern quarter of East Montpelier, separates metamorphic rocks of the Green Mountain Belt (GMB) to the west from those of the Connecticut Valley Belt (CVB) to the east. The GMB is composed of Pre-Silurian phyllites and phyllitic quartzites of the Moretown and Cram Hill Formations, and the granite bodies Dove Hill Granite and Stevens Brook Granite. The CVB is composed with phyllites (Waits River Formation), and the granite bodies Dove Hampshire Plutonic Series) comprise the CVB.

Uplands are primarily underlain by dense Pleistocene silt and fine-sand matrix glacial till. Till is thin (<20 cm in hilltops and hillside outcrops are abundant. Striations and grooves in bedrock indicate that the latest ice movement was generally to the south. Surficial deposits are mapped as Pleistocene Epoch Lacustrine deposits, Holocene Epoch alluvial deposits, and Holocene Epoch and consist of a sequence of Holocene stream deposits overlying Pleistocene lacustrine sand, silt, and silty clay deposits, which, in turn, overlie Pleistocene glacial till. Surficial geologic units are mapped in the Surficial Geology, East Montpelier map. The lacustrine and alluvial deposits define the aquifer and aquifer deposits define the data depicts into the discontinuous other deposits. This buried sand and gravel stage have significant aquifer potential. The deposits in the Kingsbury Branch valley in the eastern part of town are also thick, but are predominantly fine-grained.

The tragedy map, which portrays the thickness of overburden overlying bedrock, shows that the thickest surficial deposits are located in the Winooski River valley and in the vicinity of Berlin Pond. Most of the remaining Town East Montpelier is topographically surficial, based primarily on topography, that are locally constituted by stony, water-lowly, dense groundmass from directions towards the North Branch in the NW quarter of town and toward the Winooski River and tributaries in the SE three-quarters of town.

All accessibly-located wells in East Montpelier were completed in bedrock. On average, wells in the Silurian-Devonian rocks have the greatest yields (median = 20 gpm), followed by wells in the Ordovician-Cambrian rocks (median = 15 gpm). Wells located in the vicinity of the Winooski River Valley, where overburden thickness is <25'. We hypothesize that groundwater in the porous and permeable surficial material is interconnected and augments flow in the bedrock aquifers.

Water-level measurements were taken in 32 wells in East Montpelier, Berlin, Orange, Nitram, and Plainfield by VGS and Middlebury College (Bill, 2011). No results exceeded established standards of the Vermont Dept. of Health.

The springs(s), on property owned by Daniel Antonovich, sits on the thinly-bedded carbonate member of the Waits River Formation (DSwt1) which has average well yields of 21 gpm. The Johnson Company (1995b) suggested that groundwater that emanates from this spring(s) is derived from the underlying bedrock aquifer and that the small watersheds that encompass the spring(s) have an area of <200 acres.

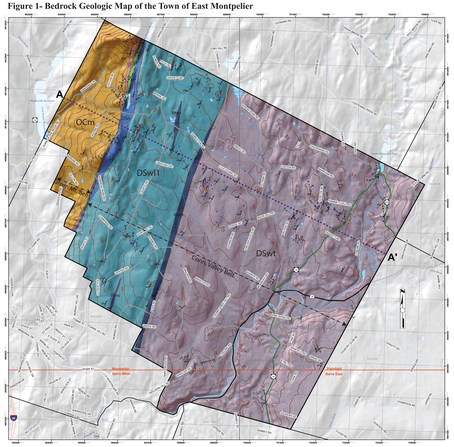
Based on the combined gauging data from the "Spring House overflow/leakage pipe and weir" and "North West Pipe" measurements, the average flow of the Antonovich Spring(s) is approximately 8 gpm. This is approximately 4 times greater than the minimum discharge in August. These data are consistent with recharge being dominated by a pulse of groundwater derived from early spring snowmelt and rainfall.

Using the average (7.2 gpm) and maximum (15 gpm) gauging results from the spring and the methods and constraining data presented in Lyons (1995), annual loss fluxes equal to 0.0127 cubic feet per second (cfs) or approximately 0.0 of the Johnson Company (1995a) or the formula Recharge Area = Total Spring Discharge per unit Total Groundwater Recharge per year, the recharge area for the spring(s) is approximately 0.0 acres. If the Johnson Company (1995a) estimate of 0.0 acres is used, and assuming a uniform distribution of negligible evapotranspiration, the adjusted average for the recharge area would only be 102 acres. The adjusted recharge area then only ranges from 111-102 acres, which is less than the combined area of the small watersheds discussed above. Because groundwater flow is not constrained by the Johnson Company (1995a) estimate, the recharge area for any given spring as well will be considerably less than would be produced by a year-long analysis.

There has been speculation that the source of groundwater feeding the spring(s) was as far away as southern Quebec. Using a simple analysis of the drainage patterns of HUC8 watersheds in the northern half of Vermont, there is no reasonable way for surface and/or groundwater from northern Quebec to reach East Montpelier or vice versa.

In 2008, the Johnson Company sampled groundwater from three springs on the Antonovich property and had these samples analyzed for Endrew Laboratories. The Vermont Geological Survey, in conjunction with partners at the Vermont Agriculture and Middlebury College, have sampled and analyzed groundwater from bedrock wells (yield are ~21 gpm) in the Waits River Formation (DSwt1) where average bedrock wells yield are ~21 gpm. These wells directly comprised the Johnson Company results with data from other wells in the Waits River Formation and found that they are not statistically different.

Figure 1- Bedrock Geologic Map of the Town of East Montpelier



Bedrock Geologic Map of the Town of East Montpelier

Compiled by Jonathan Kim from Konig (1961), Kim et al. (2003), Walsh et al. (2011), and Kim and Ruksznis (2011)

Explanation of Structural Symbols

- Strike and dip of dominant foliation: In Pre-Silurian rocks, this foliation is usually a composite foliation that includes the original bedding plane, whereas in Silurian-Devonian rocks, it is the first foliation (S1) of Acadian (Devonian) age.
- Strike and dip of bedding extremity of Konig (1961) equivalent to the first Acadian (Devonian) S1 foliation (S1).
- Strike and dip of cumulative cleavage: 1) Acadian S2 (Devonian) in Pre-Silurian rocks and 2) Acadian (Devonian) S4 in Silurian-Devonian rocks.
- Trend and plunge of stretching lineation: 1) Taconian L2 in Pre-Silurian rocks and 2) Acadian L3 in Silurian-Devonian rocks.
- Trend and plunge of crenulation lineation: 1) Acadian L1 in Pre-Silurian rocks and 2) Acadian L4 in Silurian-Devonian rocks.

References

Ern, C. Ellen, M., King, S., Hoo, C., and Parsons, J., 2003, Bedrock Geology Map of the Montpelier Quadrangle: Vermont Geological Survey Open File Map VOF-1, scale 1:24,000.

Kim, J and Ruksznis, A., 2011, Bedrock Geology of the Plainfield Quadrangle, Washington County, Vermont: Vermont Geological Survey Open File Map VOF-2, scale 1:24,000.

Konig, R.H., 1961, Geology of the Plainfield Quadrangle, Vermont: Vermont Geological Survey Bulletin #16, 37 p., 1 plate, scale 1:62,500.

Walsh, G.J., Kim, J., Ialli, M.R., and King, S., 2011, Bedrock Geology Map of the Barre and Barre East Quadrangles, Washington and Orange Counties, Vermont: U.S. Geological Survey Scientific Investigations Map 3113, scale 1:24,000.

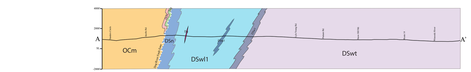


Figure 1- continued

Description of Map Units

Devonian

Dg — **New Hampshire Series Granite**
Medium-coarse-grained biotite granite composed of K feldspar, plagioclase feldspar, quartz, and biotite +/- muscovite, garnet.

Silurian-Devonian

Waits River Formation

DSwt — Thinly bedded carbonate member: rusty-weathering, locally graphitic, gray phyllites with biotite porphyroblasts (+/- garnet) that are interlayered with pasty, brown weathering, sandy marble and massive gray calcareous quartzite; these carbonate layers generally range from 0.1'-3' in thickness (0.3'-0.5' typical). Phyllite quartzite horizons are locally present. Calcareous amphibolite layers are locally present. Contains pyrite, pyrrhotite, tourmaline and chlorite veins.

DSwt1 — Rusty-weathering, locally graphitic, gray phyllites with biotite porphyroblasts (+/- garnet).

Gilman Stream Formation

DSsp — Dark gray, rusty-weathering, garnetiferous phyllite.

DSwt1 — Thinly bedded carbonate member: rusty-weathering, locally graphitic, gray phyllites with biotite porphyroblasts (+/- garnet) that are interlayered with pasty, brown weathering, sandy marble and massive gray calcareous quartzite; these carbonate layers generally range from 0.1'-3' in thickness (0.3'-0.5' typical). Phyllite quartzite horizons are locally present. Calcareous amphibolite layers are locally present. Contains pyrite, pyrrhotite, tourmaline and chlorite veins.

Northfield Formation

DSnf — Rusty-weathering, reddish, locally graphitic, gray phyllites with biotite porphyroblasts. Interlayered with phyllite quartzites and brown-weathering calcareous quartzite beds occur locally. Rarely interbedded with pasty, brown weathering, sand marble.

Silurian

Shaw Mountain Formation

Ssp — Pasty (pencil-selective) greenstone (metavolcanic) and green schist.

Ordovician

Cram Hill Formation

ODch — Dark-gray to gray carbonaceous phyllite that is locally interlayered with silvery-gray phyllite, phyllite quartzite, and greenstone. Contains greenstone layers and metadiabase and gneissose dikes or sills.

OCch — Grayish-green phyllite and phyllite: grandelit that are interlayered with gray to dark gray phyllites. This unit is transitional between the Cram Hill and Gaspe Formations. Contains greenstone layers and metadiabase and gneissose dikes or sills.

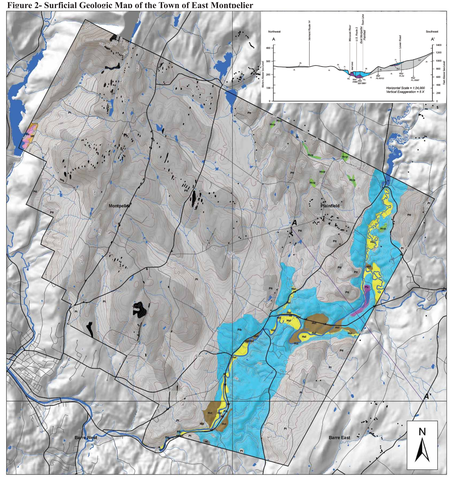
Ordovician - Cambrian

Gaspe Formation

OCGs — Interlayered grayish-green phyllites and phyllite grandelit. Locally contains more massive quartzites. Contains greenstone layers and metadiabase and gneissose dikes or sills.

OCm — Massive greenish-green quartzite and pebble conglomerate. May contain greenstone layers and metadiabase and gneissose dikes or sills.

Figure 2- Surficial Geologic Map of the Town of East Montpelier



Surficial Geology, East Montpelier

Compiled by George Springston

From Larsen (1999), Springston (2011), and Wright (1999)

Description of Map Units

Holocene Deposits

- **Hf** — Artificial Fill. Artificially emplaced earth. Common along road beds and embankments and in the more populated areas. Highly variable thickness.
- **Hd** — Holocene Alluvium. Silt, sand, pebble gravel, cobble gravel, and boulder gravel deposited by modern streams. Deposits include stream channel and/or deposits and flow-grained floodplain deposits. Minor wetland deposits are included in these deposits. Thickness is highly variable. Thickness of these deposits in the Mudwater is typically less than 3 meters.
- **Hwp** — Holocene Wetland Deposits. Peat or Muck. Thick accumulation of organic matter with minor clastic sediment. Wetlands with organic sediment at least 0.5 meter thick.
- **Ht** — Holocene Stream Terrace Deposits. Silt, sand, pebble gravel, cobble gravel, and boulder gravel deposited on terraces above the modern floodplains of streams. They represent former floodplains that have been disrected by younger streams. Generally less than 5 meters thick.
- **Hk** — Holocene fan-terrace deposits. Pebble and cobble gravel and pebbly sand deposited on top of alluvial fan deposits of glacial Lake Winooski subsequent to drainage of the lake. The gravel and sand are commonly less than 3 meters thick.

Pleistocene Deposits

- **Pv** — Pleistocene Lake Deposits, Coarse-grained. Very fine to medium sand deposited in shallow waters or on shoulders of glacial Lake Winooski. Thickness can range from less than a meter on the valley sides to several meters or more in the valley bottoms.
- **Pb** — Pleistocene Lake Bottom Deposits. Clay, silty clay, clayey silt, and silt with minor sand deposited in Lake Winooski. Silt and sand layers (silty clay or clay) alternating with coarser-grained layers (clayey silt and coarser) that are interpreted as annual deposits (varves) in glacial Lake Winooski. Thickness varies from less than one meter to greater than 10 meters.
- **Pc** — Pleistocene Ice-contact Deposits. Pebbly medium to coarse sand and pebble, cobble, and boulder gravel deposited in contact with glacial ice. Largely composed of material reworked from tills. Generally less than 20 meters thick. Moderate to good aquifer potential.
- **Pt** — Pleistocene Till. Dense silt-matrix to fine-sand-matrix till. Thickness is highly variable, from less than 1 meter to greater than 30 meters.
- **Pm** — Pleistocene Till. This. Descriptions are in preceding unit. Thickness highly variable but generally less than 5 meters and bedrock outcrops are common.

Explanation of Map Symbols

- Cross Section Line
- Bedrock Outcrops
- Bedrock Outcrops
- 7.5 Minute Quadrangles
- 100 foot Contours
- 20 foot Contours
- Streams
- Water Bodies
- Major Roads
- Minor Roads

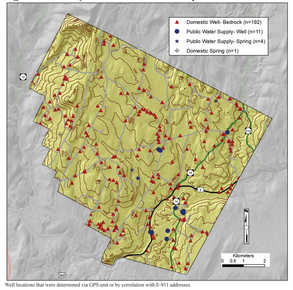
References

Larsen, F.D., 1999, Surficial geologic map of the Montpelier quadrangle, Vermont: Vermont Geological Survey Open File Report VOF-1, Vermont Geological Survey, Waterbury, 1 CD-ROM.

Springston, G., 2011, Surficial geologic map of the Plainfield quadrangle: Vermont Geological Survey Open File Report VOF-2, Vermont Geological Survey, Waterbury, scale 1:24,000.

Wright, Stephen, 1999, Surficial geologic map of the Barre West quadrangle, Vermont: Vermont Geological Survey Open File Report VOF-3, Vermont Geological Survey, Waterbury, scale 1:24,000.

Figure 3- Accurately Located Wells in East Montpelier



Well locations that were determined via GPS unit or by correlation with E-911 addresses.

Figure 4- Wells Yields for Bedrock Wells

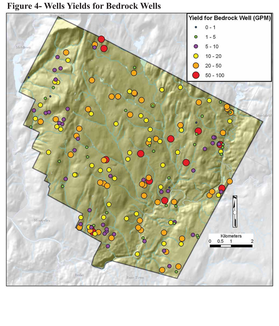
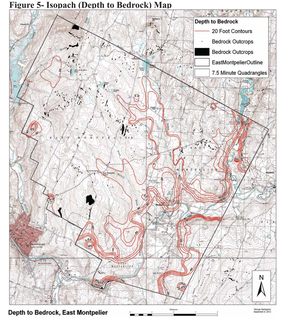


Figure 5- Isopach (Depth to Bedrock) Map



Depth to Bedrock, East Montpelier

Figure 6- Generalized Potentiometric Map

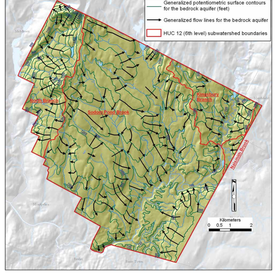
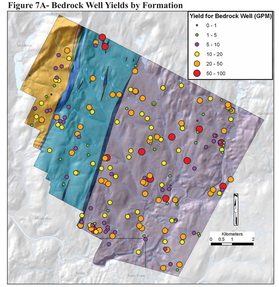
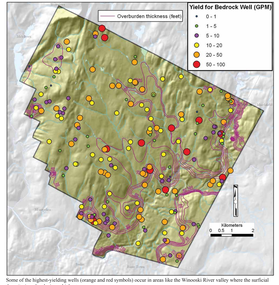


Figure 7A- Bedrock Well Yields by Formation



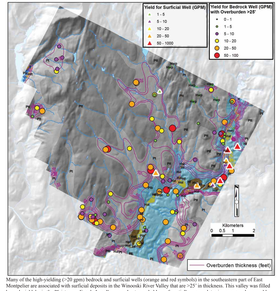
See Figure 7B for the average yields by bedrock formation.

Figure 8A- Bedrock Well Yields on Isopach (Depth to Bedrock) Map



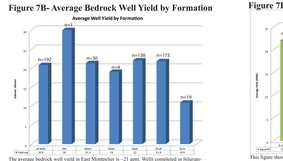
Some of the highest-yielding wells (orange and red symbols) occur in areas like the Winooski River valley where the surficial deposits (overburden) are thicken.

Figure 9- Well Yields, Isopach Map, and Surficial Geologic Map



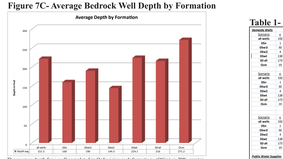
Many of the high-yielding (>20 gpm) bedrock and surficial wells (orange and red symbols) in the southeastern part of East Montpelier are associated with surficial deposits in the Winooski River Valley that are >25' in thickness. This valley was filled by a glacial lake in the Pleistocene Epoch. Locally, groundwater probably preferentially accumulates in porous and permeable horizons in these glacial lake deposits to form surficial aquifers of limited extent. High-yielding surficial wells in this area support this. In addition, we suspect that groundwater from these surficial deposits leaks downward and boosts the yield of the underlying bedrock aquifer.

Figure 7B- Average Bedrock Well Yield by Formation



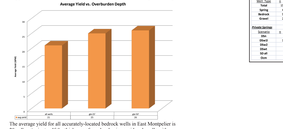
The average bedrock well yield in East Montpelier is ~21 gpm. Wells completed in Silurian-Devonian formations (SDsf) of the Connecticut Valley Belt have yields that are approximately double those completed in the older Ordovician-Cambrian formations (OCm) of the Green Mt. Belt. We believe that the higher well yields in the Silurian-Devonian rocks are related to the abundant marbles; the calcite in these marbles dissolves during weathering processes to create significant secondary porosity.

Figure 7C- Average Bedrock Well Depth by Formation



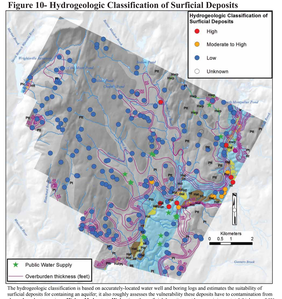
The average depth for a well completed in Ordovician rock formations (OCm) is 20% greater than a well completed in Silurian-Devonian rock formations (DSwt,DSwt1,DSwt2, and DSnf = SDsf). This is presumably related to the fact that the Ordovician rocks have lower average yields and that greater depths need to be drilled to access a sufficient water quantity.

Figure 8B- Average Bedrock Well Depths by Formation



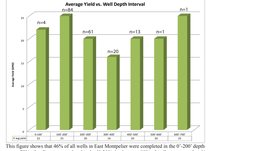
The average yield for all accurately-located bedrock wells in East Montpelier is 20 gallons/ minute. If the thickness of overburden is considered, wells with greater than/equal to 25' have yields that exceed the average by 19%. Wells with overburden than is greater than/equal to 50' have 24% higher yields than the average well. Figure 9 shows the distribution of bedrock wells with greater than/equal to 25' of overburden.

Figure 10- Hydrogeologic Classification of Surficial Deposits



The hydrogeologic classification is based on accurately-located water well and boring logs and estimates the suitability of surficial deposits for containing an aquifer; it also roughly assesses the vulnerability these deposits have to contamination from above. In order to receive a ***High*** or ***Moderate to High*** rating, the surficial deposits must have a minimum total thickness of 40' and a significant proportion of porous and permeable coarse-grained materials. Wells ranked as ***High*** have thick, fine-grained surficial deposits that are locally capped by a thin layer (<10') of coarse-grained material. The fine-grained material provides the material, but the coarse-grained material is not overlain by a protecting layer of fine-grained material and thus may be at greater risk of contamination. Wells ranked as ***Low*** have either a thick section of fine-grained material that is unlikely to produce much water or else a thin (less than 40 feet) total thickness of surficial materials (wells with such few thicknesses have been found to be poor sources and/or are at risk of contamination from surface water). The wells classified as ***Unknown*** had insufficient details in their logs. The clustering of ***High and Moderate to High*** wells in the Winooski river valley suggests that there may be some limited potential for developing sources of water in these surficial materials. However, the deposits would need to be evaluated in significantly greater detail to confirm the existence and vulnerability of these potential aquifers.

Figure 7D- Average Bedrock Well Yield by Depth Interval

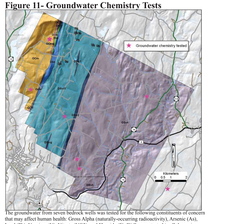


This figure shows that 46% of all wells in East Montpelier were completed in the 0'-200' depth range; 78% of wells were completed in the 0'-300' depth range; 88% of wells were completed in the 0'-400' depth range; and 95% of wells were completed in the 0'-500' depth range. Although this data may be of general interest in determining how much one might spend to drill a well in East Montpelier, the yield by bedrock formation is better at approximating the expected well depth in a specific area.

Table 1- Statistics for Domestic and Public Wells in East Montpelier

Domestic Wells											
Formation	n	%	Total yield	Median yield	Max yield	Overburden (ft)	Median OB (ft)				
all wells	192	100	3,973	20.5	225	1,811	17.0	9.4			
DSwt	138	72	2,863	20.0	225	1,311	17.0	9.5			
DSwt1	4	2	80	19.5	40	31	8.0	7.8			
DSnf	35	18	1,000	25.0	200	300	18.0	8.6			
OCm	4	2	27	6.5	15	38.7	17.0	9.7			
OCGs	19	10	415	20.0	150	96.7	20.0	9.0			
OCch	4	2	68	17.0	40	25.0	17.0	8.2			
ODch	1	1	20	20.0	20	17.0	17.0	8.2			
Isopachs	%	Total yield	%	Median yield	%	Max yield	%	Median OB	%	Median DTB	%
all wells	192	100	3,973	100	20.5	100	225	100	17.0	100	9.4
0to5	5	3	100.0	2	20.0	2	20.0	2	0.0	0	8.0
5to10	8	4	160.0	4	20.0	4	20.0	4	0.0	0	8.0
10to20	37	19	740.0	19	20.0	19	20.0	19	0.0	0	8.0
20to50	92	48	1,840.0	46	20.0	46	20.0	46	0.0	0	8.0
50to100	50	26	1,000.0	25	20.0	25	20.0	25	0.0	0	8.0
Isopachs	%	Total yield	%	Median yield	%	Max yield	%	Median OB	%	Median DTB	%
all wells	192	100	3,973	100	20.5	100	225	100	17.0	100	9.4
0to5	5	3	100.0	2	20.0	2	20.0	2	0.0	0	8.0
5to10	8	4	160.0	4	20.0	4	20.0	4	0.0	0	8.0
10to20	37	19	740.0	19	20.0	19	20.0	19	0.0	0	8.0
20to50	92	48	1,840.0	46	20.0	46	20.0	46	0.0	0	8.0
50to100	50	26	1,000.0	25	20.0	25	20.0	25	0.0	0	8.0
Public Water Supply											
Aquifer of tested wells											
DSwt	6	55	1,200.0	55	200.0	55	300.0	55	100.0	55	100.0
DSwt1											
DSnf											
OCm	5	45	1,000.0	45	200.0	45	300.0	45	100.0	45	100.0
OCGs											
OCch											
ODch											
Well Type	%	Total yield	%	Median yield	%	Max yield	%	Median OB	%	Median DTB	%
Drilled	5	45	1,000.0	45	200.0	45	300.0	45	100.0	45	100.0
Dug											
Spring											
Unknown	6	55	1,200.0	55	200.0	55	300.0	55	100.0	55	100.0
Bedrock											
Well Type	%	Total yield	%	Median yield	%	Max yield	%	Median OB	%	Median DTB	%
Drilled	5	45	1,000.0	45	200.0	45	300.0	45	100.0	45	100.0
Dug											
Spring											
Unknown	6	55	1,200.0	55	200.0	55	300.0	55	100.0	55	100.0
Bedrock											
Private Services											
Aquifer											
DSwt											
DSwt1											
DSnf											
OCm											
OCGs											
OCch											
ODch											
Well Type	%	Total yield	%	Median yield	%	Max yield	%	Median OB	%	Median DTB	%
Drilled											
Dug											
Spring											
Unknown											
Bedrock											
Well Type	%	Total yield	%	Median yield	%	Max yield	%	Median OB	%	Median DTB	%
Drilled											
Dug											
Spring											
Unknown											
Bedrock											

Figure 11- Groundwater Chemistry Tests



The groundwater from seven bedrock wells was tested for the following constituents of concern that may affect human health: Gross Alpha (naturally-occurring radioactivity), Arsenic (As), Lead (Pb), Uranium (U), Nitrate (NO3), and Fluoride (F). Wells were tested in all the major bedrock formations in East Montpelier. None of the wells exceeded any standard for any of these constituents (Daly, 2012).

References

Brooks, E., 2011, Geochemistry and Radionuclide Potential in a Fractured Bedrock Aquifer System, Craftsbury, Vermont: Unpublished BA thesis, Middlebury College, 39 p.

Daly, R.N., 2012, Geochemistry of Groundwater and Bedrock in the Plainfield Quadrangle, Vermont: Unpublished BA thesis, Middlebury College, 41 p.

The Johnson Company, 1995a (2/13/95), Montpelier Springs: Recharge Area Calculations (and maps), 4 pages.

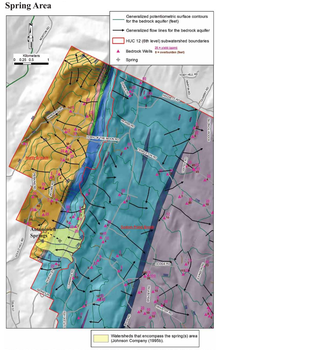
The Johnson Company, 1995b (7/19/95), Memo to Kathy Fallon of the DEC (Vermont) Water Quality Division, 6 pages.

The Johnson Company, 1995c (9/13/95), Memo to Kathy Fallon of the DEC (Vermont) Water Quality Division, 5 pages.

The Johnson Company, 2000, Summary and report of fund laboratory data (from Endyne Laboratory Services) to Daniel Antonovich, 6 pages.

Vermont Geological Survey and Vermont Agency of Agriculture, 2003, unpublished groundwater geochemical data from East Montpelier

Figure 12- Integration of Data Sets for the Antonovich Spring Area



Based on this integrated map, the Antonovich spring(s) is : 1) located in the thinly-bedded carbonate member of the Waits River Formation (DSwt1) where average bedrock wells yield are ~21 gpm; 2) located in the North Branch (HUC12) sub-watershed where surface and groundwater flow is generally to the the west-northwest; 3) encompassed by two small watersheds with a total area of 227 acres (Johnson Company, 1995b); 4) derived from discharge from the underlying bedrock aquifer (Johnson Company, 1995b).

Figure 13- Gauging Data for the Spring (Johnson Company, 1995c)

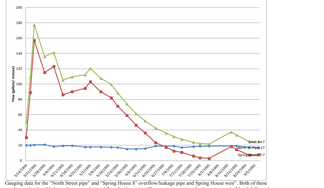
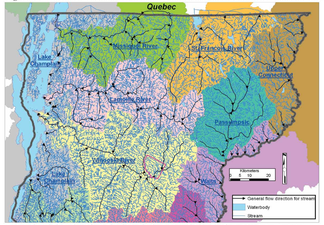


Figure 14- Northern Vermont Watersheds and Generalized Flow Directions for Streams



"A watershed is a basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys. A watershed carries water "downhill" from the land after rain falls and snow melts. Drop by drop, water is channelled into soils, groundwaters, creeks, and streams, making its way to larger rivers and eventually the sea (http://www.watersheddata.org/fs_indexwatershed.html)". Watersheds are found throughout Vermont. The Town of East Montpelier is located in the Winooski River Watershed. Surface and groundwater flows from 1) mini-small streams, 2) into tributaries of the Winooski, 3) into the Winooski River and then 4) into Lake Champlain. Black arrows show the generalized directions of surface water flow in each watershed. Using this simple map, it is unreasonable to expect that groundwater or surface water from Quebec could make its way into the Winooski River Watershed, no less the Town of East Montpelier.

Table 2- Groundwater Chemistry Comparison

Parameter:	Antonovich Spring average	Antonovich Spring std dev	Antonovich Spring median	Lake Groom Rd. Well(s) (DSwt) average	Lake Groom Rd. Well(s) (DSwt) std dev	Craftsbury Well(s) (DSwt) median	PG(TW)Well(s) (DSwt) average	PG(TW)Well(s) (DSwt) std dev	PG(TW)Well(s) (DSwt) median	Comments
pH	7.2	0.3	7.1	7.21	0.06	7.6	6.28	7.16	0.93	
Chloride (ppm)	5.0	2.0				10.0	10.0	0.0	10.0	
Nitrogen, Nitrate (ppm)	2.28	0.41				0.076	0.127	0.09	1.43	
TDS (ppm)	112.00	101.90								
Sulfate (ppm)	19.1	10.5				11.7	4.2			
Arsenic (ppm)	0.001			0.001		0.001		0.001		detection limit for all samples
Uranium (ppm)	0.5	8.5		0.5	0.5	0.5	24.25	0.51		
Total Hardness (CaCO3)	89	35		187	44	92	142	77		
Magnesium (ppm)	3.8	0.8		5.7	2.1	11.7	4.1			
Manganese (ppm)	0.005			0.342	0.538	0.022	0.031	0.013	0.025	
Potassium (ppm)	0.87	0.20		0.71	0.37	0.59	0.24			
Selenium (ppm)	0.005	0.005		0.005		0.005				detection limit for all samples
Sodium (ppm)	6.55	1.37		6.55	4.00	5.55	7.16	19.12	20.07	
Zinc (ppm)	0.01			0.01		0.01	0.000			detection limit for all samples

The Johnson Company (2000) sampled groundwater from 3 springs on the Antonovich property (Antonovich Spring) and had these samples analyzed at Endyne Laboratories. The Vermont Geological Survey, in conjunction with partners at the Vermont Agency of Agriculture and Middlebury College, have sampled and analyzed groundwater from bedrock wells (yield are ~21 gpm) in the Waits River Formation (DSwt1) where average bedrock wells yield are ~21 gpm. These wells directly comprised the Johnson Company results with data from other wells in the Waits River Formation. Comparing these data sets, we found that the Antonovich spring chemistry was not statistically different from that of other wells in the Waits River Formation. (Lyle Young Rd. wells = 2005, unpublished data, Vermont Geological Survey and Vermont Agency of Agriculture; Craftsbury Wells = Brooks (2011), PG(TW) Wells (Plainfield Quadrangle/East Montpelier Wells) = Daly (2012)).