THE SURFICIAL GEOLOGY
AND
HYDROGEOLOGY
OF
DORSET, VERMONT

By

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Introduction

Field work for this project was carried out during the 2006 and 2007 field seasons. Data analysis and map revisions were done in 2008 and completed in 2009. Maps discussed in this report are:

1. Surficial Geology
2. Stratigraphic Cross Sections
3. Field Data Sites
4. Springs, Seeps & Water Well Locations
5. Deglacial History
6. Depth to Bedrock
7. Bedrock Topography
8. Discharge Areas and Possible Shallow Overburden Aquifers
9. Hydrogeologic Units
10. Recharge Potential to Bedrock Aquifer
11. Potentiometric Surface Map and Groundwater Flow Lines

Location and Geologic Setting

The town of Dorset encompasses portions of the West Rupert, Manchester, Peru, Dorset and Danby 1:24000 topographic quadrangles and covers approximately one quadrangle of area.

Two major valleys separate three upland regions. The Dorset Valley trends northwest and contains the West Branch Batten Kill that flows southeast into Manchester. In the vicinity of Dorset Village, there is a broad drainage divide consisting of wetlands. North of this divide, the Mettawee River enters the valley from head waters in the central upland region and flows northwest into New York. The upper Mettawee River represents a notable east-west tributary valley referred to as Mettawee Hollow.

In the east, the East Dorset Valley trends north-northeast and is a continuation of the Vermont Valley. The Batten Kill flows southward from a divide just north of the village of East Dorset. Otter Creek flows northward from this drainage divide toward Wallingford. Both major valleys are underlain predominantly by Cambrian through Ordovician carbonate rocks including limestone, marble and dolomitic marble that comprise the Champlain Valley Sequence (CVS). There are some quartzite interbeds in the carbonate valley rocks, especially the Monkton formation. The forthcoming new State bedrock geology map (Ratcliffe et. al., in review) best displays the current interpretation of the distribution of major rock types, their ages and the structural relationships in the rock.

The southwest corner of town rises moderately up the flanks of Mother Myrick Mountain, part of the Taconic Mountains, whose 3,361 ft summit is just south of the town boundary. Goodman, Gilbert and Daley Brooks drain the mountain flank and cut through Taconic Sequence (TS) lithologies composed of schist and phyllite above approximately 2,400 ft elevation with some interbedded carbonates. Below this elevation, the mountain flank is underlain by Cambro-Ordovician carbonate lithologies of the CVS with a major Taconian thrust fault separating the distinct lithologies of these 2 sequences.

The eastern edge of the town rises steeply up the flank of the Green Mountains toward the summit of Mount Tabor and Bromley Mountain, both beyond the town boundary. Elevation exceeds 2,400 ft and the steep slopes are underlain predominantly by the Cambrian Cheshire quartzite, considered part of the CVS. Little Mad Tom, Mad Tom and Mt. Tabor Brooks descend steeply along the Green Mountains flank into the East Dorset Valley. In the extreme eastern portion of the town, the oldest Pre-Cambrian gneiss of the Green Mountain Sequence (GMS) is exposed above the Cheshire quartzite.

A large central upland region of the town separates the Dorset and East Dorset valleys and can be informally called the Dorset Mountains. This includes the summits of Owl's Head (2,481 ft), Green Peak (3,230 ft), Dorset Hill (2,782 ft), Netop Mountain (2,875 ft) and the south summit of Dorset Peak at approximately 3,730 ft. This upland region is underlain by Taconic Sequence lithologies composed of phyllite and schist above a major Taconian thrust fault. Kirby Hollow, Dorset Hollow and several unnamed tributaries form the head waters of the Mettawee River.

Surficial Geology

The Surficial Geology map shows the observed and inferred contacts between sediment types based upon field data sites and interpretation of aerial photographs and soils maps. The general distribution of surficial materials enabled the interpretation of the deglacial history of the town. This interpretation was guided by the recent completion of mapping in Manchester (De Simone, 2004), Arlington (De Simone, 2001) and Wallingford (De Simone, 2005) which establishes the new regional framework for understanding the glacial geology of southwestern Vermont.

The Green Mountains, Dorset Mountain and Taconic Mountain summits and ridge lines are underlain by a very thin veneer of till with frequent outcrops. The steep mountain flanks are similarly underlain by till veneer with less frequent outcrops. The carbonate rocks on the Taconic and Dorset mountain flanks tend to outcrop in a series of cliffs separated by steps or ledges. The Green Mountain flanks are underlain chiefly by quartzite with less frequent outcrops and few or subtle ledges.

A thick till blanket occurs along the lower flanks of the mountains. The topography typically reveals the contact between thick and thin till as a small but distinctive break in slope along a mountain flank. Below this slope break, outcrops are less frequent due to the thicker till blanket. The thick till-thin till contact also roughly coincides in places with the trace of the major Taconian thrust fault along the Taconic and Dorset mountain flanks. This thick till blanket may not be present everywhere as both mapping and well logs indicate. In those areas where significant flow of glacial meltwater away from the lateral margin of the glacier occurred, there are kame terraces composed of gravel and sand sediment. In these areas of ice contact deposits, there is little or no till visible at the surface. Till may exist under the kame terrace deposits or these gravel and sand sediments may persist for many tens of feet all the way to rock.

Ice contact and glaciofluvial sediment predominate in the valleys. Two small areas of moraine and kame moraine at the southern margin of town represent still stands or minor surge margins of the Dorset valley glacier and East Dorset valley glacier. For reference purposes, the latter valley glacier was called the Danby glacier in the 2004 Manchester report. These sediments occur in the vicinity of Morse Hill Road. Ice contact stratified sands and gravels occur along the lower valley flanks in both the Dorset and East Dorset valleys. Mettawee Hollow contains a series of stepped kame terraces along the northern valley bottom that are composed of glaciofluvial sand with gravel. Thick ice marginal deposits occur just north of Dorset Village and at North Dorset. Both of these sites represent still stands of the respective retreating valley glaciers. The head of outwash at Dorset is beautifully kettled and links to a lateral margin kame terrace. The North Dorset ice margin is a site of extremely thick ice contact sediment with esker deposits and a notable former stagnation zone that heads at Emerald Lake, a large kettle depression with several other large kettles to the south. Much of the Dorset and East Dorset valley bottoms consist of outwash sands and gravels that form a prominent sandur or valley train – both terms used to describe the gently sloping landform - of outwash. Mettawee Hollow contains a similar valley train of sands and gravels that descends along the southern margin of the hollow and merges with the Dorset valley outwash. This deposit represents inwash as the distal portion of this inwash was deposited against or along the Dorset valley glacier. Inwash differs from outwash in that the waters transporting and depositing the sediments flow back toward and/or against the ice for inwash but flow away from the glacier for outwash.

Modern stream dissection has resulted in alluvium along the present flood plain with some slightly higher fluvial terraces. Alluvial fans occur where a few of the tributaries enter the major valleys. Minor colluvium from landslides was recorded in a few places but was not a mappable unit. However, better exposure might reveal that landslide deposits are more frequent along the lower mountain flanks as the terrain frequently exhibits the appearance of old slides with boulders fallen from higher and steeper slopes and a "mixed" texture of the sediments. Wetlands with muck and peat occur in the Dorset swamp area and in the large kettles south of Emerald Lake.

Deglacial History

A sequence of 2 ice margins is recognized through town that records brief still stands of the retreating valley ice. Most geologists believe the ice retreated quite rapidly from Vermont and adjacent parts of New York and New England. Where dates from organic materials are available, these data confirm the ice retreated at rates in the Champlain Lowland approaching 0.4-0.5km/yr (De Simone et al, 2008, Franzi et al, 2007). If similar rates of retreat held true for the ice in the Dorset valleys, then ice retreat may have been accomplished in as little as 15-20 years. The 2 ice margins are:

1. South Dorset ice margin (position A)
2. Dorset ice margin (position C and C1-C2)

Positions B, B1 and B2 represent intermediate "steps" in the retreat of the ice from the South Dorset to the Dorset ice margins. Position B in the Dorset valley represents a step in the retreat which resulted in a lower set of kame terraces in Mettawee Hollow. Positions B, B1 and B2 in the East Dorset valley represent steps in the retreat which enabled the esker, kame moraine and kame terrace sediments mapped to accumulate in a sequential fashion.

The moraine and kame moraine deposits in the Morse Hill Road area define the first ice marginal positions recognized on the <u>Deglacial History map</u>. These were previously identified during mapping in Manchester and named the South Dorset Ice Margin. The exposed sediment south in Manchester of the Dorset glacier moraine consists of interbedded diamicton and stratified fluvial sediment. The deformation in the diamicton is consistent with sediment flow origins but also may be the result of a minor surge of the Dorset glacier during its retreat. A similar ridge was mapped as moraine and was deposited by the East Dorset glacier and is inferred to be contemporaneous. This latter ridge is not well exposed. Meltwater from these ice margins deposited outwash through Manchester Center.

The Dorset and East Dorset glaciers retreated to the Dorset and North Dorset ice positions, respectively. The extensive ice marginal deposits described above accumulated during this relatively long still stand. This is named the Dorset Ice Margin. Sedimentation associated with this still stand defined the present drainage divides in both the Dorset and East Dorset valleys. As the Dorset glacier maintained this ice position, retreat and down wasting of ice in Mettawee Hollow resulted in a series of stepped kame terraces. Each kame terrace likely records a local and small ice marginal lake in Mettawee Hollow. These unnamed minor lakes apparently drained back under the Dorset ice rather than spilling over the divide between the valleys. The lakes were likely very short-lived and no surficial fine grained lacustrine sediments were observed. However, well logs record fine grained sediments that represent deposition into these small, local lakes. Final melting of the Mettawee Hollow ice allowed inwash and an inwash fan of gravel and sand to be deposited against the Dorset valley glacier in the east part of Dorset village. This Mettawee Hollow ponded water drained through the pass at approximately 1000ft elevation where the lower portion of Dorset Hollow Road is today.

In the East Dorset valley, thick gravel and sand was deposited through the North Dorset area, especially from a meltwater and/or meteoric water source along the west margin of the glacier. This is where the overburden thickness approaches 300ft and where well logs indicate the sediment is predominantly permeable. While mapped as part of the kame moraine, the surface of the deposit just west of North Dorset has a fan type appearance that might have resulted from a meteoric contribution to the top of the ice contact meltwater sediment toward the end of deposition. Alternatively, the sediment could have been derived from meltwater originating higher on the glacier surface to the north and flowing into the Gulf Brook drainage basin and back against the ice as a late stage fan deposit atop the thick ice contact sediment. Regardless, the final result is an area of the thickest gravel and sand sediment accumulation in the town.

Mapping supports De Simone's (2004) conclusion that there was no Glacial Lake Batten in the Batten Kill valley extending south through Manchester toward Arlington. Rather, the sediments consist of typical outwash deposited in a subaerial environment.

Retreat of both the Dorset and East Dorset glaciers resulted in the establishment of ice marginal lakes in their respective valleys. Glacial Lake Emerald (De Simone, 2005) is named because ponded waters in the Otter Creek drainage basin flowed across the spillway at the Emerald Lake divide. Retreat of the Dorset glacier allowed Mettawee basin waters to pond in front of the ice. This established a Glacial Lake Dorset with a spillway through the broad drainage divide to the Batten Kill basin. The previously deposited outwash was dissected and an inset outwash or valley train was deposited through Manchester. This can be seen as a lower outwash surface through Manchester Center to Manchester. These sediments are technically not outwash as they resulted from lake outflow that eroded and re-deposited previously deposited outwash sediments. The modern streams in the drainage divide are underfit. It is not believed this spillway was used for a long time. Rather, it is believed that a lower outlet for Lake Dorset and the establishment of a new glacial lake in the Mettawee basin occurred fairly quickly as the Dorset ice retreated beyond Rupert and into New York State. This is the initial phase of the lake previously mapped through the Granville area by De Simone (1985) and referred to as Glacial Lake Granville. More mapping is needed in the down valley region to discern if there were distinct levels to Lake Granville with identifiable outlets.

The Luzerne Readvance Question

Connally and Cadwell's (2002) depiction of the Luzerne readvance in eastern New York takes the limit of the readvance as far south and east as Mt. Equinox. Therefore, evidence for a readvance was a possibility considered during mapping of Arlington, Manchester and Dorset as glaciological considerations would have made readvance of "Luzerne" ice into the Mettawee and Batten Kill valleys highly likely. There was evidence for a minor surge of ice associated with the South Dorset Ice Margin as discussed above and in De Simone (2004). However, the evidence is not of the type associated with a larger surge or ice readvance as envisioned by Connally. Indeed, the deformation in the moraine may well be solely the result of sediment flow in a typical ice marginal setting. The occurrence of extensive deformed till in other places such as northern Vermont where the Bridport surge of the Hudson-Champlain Lobe occurred is taken as the necessary proof of a readvance. No such proof exists in the Vermont Valley precisely where Connally's depiction of the Luzerne readvance would place the readvance limit. Therefore, it is concluded here that the Luzerne readvance did not occur as most recently envisioned by Connally. This brings into question the validity of the entire Luzerne readvance as an event in the deglaciation of the Hudson-Champlain Lowland. Further mapping in the Mettawee drainage basin may shed additional light on this important question.

De Simone (2008) has concluded from extensive mapping of Washington County, NY, and from analysis of the type section for the proposed readvance west of Glens Falls, NY, that the Luzerne readvance did not occur and that the hypothesis should be abandoned.

Depth to Bedrock

The located well data were analyzed and erroneous or default entries in the depth to bedrock column were amended using other data contained in the well logs to produce the best available data set to interpret overburden thickness. Overburden thickness is shown on the Depth to Bedrock map where areas of thickest accumulation of overburden occur due to till and/or meltwater deposition. The contour interval is 20 feet but in the North Dorset area there is overburden nearly 300' thick; a 100' contour interval was necessary there to prevent the map from being too cluttered to see any thickness contours.

The areas of thick *permeable* sediments can be identified using the surficial geologic map and analysis of the well logs. This is valuable because such thick permeable overburden areas are best prospects for overburden aquifers. Thick outwash and ice contact deposits occur in the Dorset and East Dorset valleys. The thickest sediments were deposited in association with the Dorset Ice Margin. These thick glaciofluvial deposits occur at Dorset Village and at North Dorset. At Dorset Village, sand and gravel deposits approach and slightly exceed 100' thickness. At North Dorset, glaciofluvial deposits approach 300' thickness as revealed by several well logs. These two locations and a third area of thick overburden in the vicinity of Mad Tom and Little Mad Tom brooks are considered 3 of the best prospects for overburden aquifers in Dorset. Overburden aquifers in thick permeable sand and gravel deposits can provide large quantities of water and their potential may warrant further investigation.

Bedrock Topography

The Bedrock Topography map reveals the pathways of the major preglacial valleys that coursed through town. The map was generated by subtracting the contoured overburden thicknesses from the surface elevations to determine the elevation of bedrock. These same elevations exist as point data in the well logs calculated by subtracting the depth to bedrock elevation from the estimated elevation of the well head as interpreted from the topographic map.

The data reveal the preglacial bedrock divide in the Dorset Valley is much closer to South Dorset village than to the present surface drainage divide that is very near Dorset village.

The preglacial drainage divide in the East Dorset Valley appears to be very near the present surface drainage divide between Otter Creek and the Batten Kill. The Mad Tom and Little Mad Tom tributary valleys appear to be hanging valleys above the deeper East Dorset glacial trough. The resistant quartzite rock outlier east of Emerald Lake pinches the East Dorset Valley and likely encouraged the retreating glacier to pause during retreat and develop the extensive ice contact sediment accumulation seen through the Emerald Lake region.

The practical value of the bedrock topography map is similar to the depth to bedrock map discussed above. The map can be used to discern the areas of thickest overburden but also to trace or track the deepest portion of the buried bedrock valleys through town. This may be valuable as the bottoms of the buried bedrock valleys may be areas where permeable overburden from the most recent or even from older glaciations may be preserved. Such permeable overburden, if present, would represent a potential deep or buried overburden aquifer resource. such aquifers can be excellent water sources and may have a protective layer of finer grained sediments that could inhibit downward movement of any contaminants.

Stratigraphic Cross Sections

The stratigraphic cross sections were drawn across the 3 areas of thick overburden identified above and are located on the Stratigraphic Cross Sections map. The available well data indicate the overburden in these 3 cross valley profiles consists predominantly of stratified sand and gravel with only minor amounts of clay and/or hardpan indicated in a very few logs. The cross sections collectively reveal a paucity of till and a valley filling sequence of permeable sand and gravel sediment. Therefore, these valleys are sites of shallow or unconfined overburden aquifers. In the South Village Pond section, 5 gravel wells or wells that possibly have combined contribution from gravel and carbonate rock average 40 GPM yield. In the North Dorset section, 7 similar wells average 65 GPM yield with 2 wells having 100 GPM yield. In the Dorset portion of the Dorset-Mettawee Hollow section, 3 similar wells average 66 GPM yield with 1 well having a 100 GPM yield.

Discharge Areas and Possible Shallow Overburden Aquifers

Surficial geologic mapping, analysis of well logs, and interpretation of overburden thickness and stratigraphic cross sections enabled the preparation of the Discharge Areas and Possible Shallow (Overburden) Aquifers map. The possible extent of shallow or unconfined overburden aquifers is outlined. Areas of thickest overburden, ≥60ft, are highlighted within an outline of the extent of possible overburden aquifers. This indicates those regions where there is the greatest potential for a high yielding overburden well that may be suitable to develop.

Recharge to the shallow and unconfined overburden aquifers occurs by direct infiltration of precipitation through permeable surface deposits of gravel and sand. In addition, interaction between surface streams and an overburden aquifer can be complex and may provide additional recharge, indirect recharge. The higher flanks of the valleys with thin till and/or exposed rock may contribute a large flow to surface stream runoff. When these streams spill out of the mountains onto the valley floor, there may be a reach of the stream crossing the permeable surficial deposits. Indirect recharge by leakage of water through the beds of the streams is possible. A given reach of a stream may filter water through the stream bed and recharge the shallow aquifer below.

Data from the Neshobe River in Brandon, VT, verifies this process of indirect recharge occurs in a similar setting to many smaller streams in Dorset. Mad Tom and Little Mad Tom brooks both empty out onto the valley floor in places underlain by largely permeable sediment. These places warrant further study for possible indirect recharge. The Batten Kill is a losing stream in portions of Manchester and Arlington based upon older work of students. A high yield overburden well is a possibility that should be investigated for Dorset, perhaps sited in a place where a surface stream may be contributing recharge to the aquifer below. Dorset presents conditions similar to those in Manchester where that town has developed a thick unconfined overburden aquifer as a public water supply.

The topographically lowest surface portions of the overburden aquifer are along the present stream drainages, ponds and wetlands where the water table intersects the ground surface. These wetlands and ponds serve as aquifer discharge areas and are shown on the map.

Hydrogeologic Units

Data from the Centennial Geologic Map of Vermont (Doll, 1961), Bedrock Geology of the Pawlet Quadrangle, Vermont (Shumaker and Thompson, 1967), Geology of the Equinox quadrangle and vicinity, Vermont (Hewitt and LaBrake, 1961), and more recent mapping (USGS, 2006, open file) were used to generate the Hydrogeologic Units map. The map portrays the distribution of the major hydrogeologic units defined by grouping major lithologic units according to geologic sequences.

Champlain Valley Sequence (CVS); The Champlain Valley Sequence (CVS) includes predominantly carbonate rocks with some interbedded quartzite. These carbonates and quartzites underlie the majority of the valley bottoms and extend part of the way up the valley flanks. Carbonate rocks here, as elsewhere in Vermont, are generally fractured with high secondary permeability due to the interconnected nature of these fractures. Additionally, surface exposures reveal considerable evidence of dissolution, typical for carbonate rocks in a humid temperate climate. Dissolution enlarges fractures and opens spaces along bedding planes in carbonate rocks. Evidence of this dissolution can easily be seen at the large outcrop along Rte 7 near Emerald Lake. The outcrop at the junction of Rte 7 and Rte 7A also shows evidence for dissolution along the top of the outcrop where fractures have been enlarged. The most illuminating and dramatic evidence for carbonate dissolution can be seen throughout the area where the Evans-de Knotbeck Spring occurs. Here, the spring issues from carbonate rock atop a bench in the carbonate rock. The surface of this rock bench is criss-crossed with solutionally enlarged fractures. The stream formed by the spring flows only a very short distance and disappears into a very large sinkhole in the carbonate rock. All of these dissolution features verify the presence of karst developed in the carbonate rocks. The karst may not be as dramatic as that in Kentucky or Tennessee where the caverns are very large but the karst exists here in Dorset. It is likely that karst has been preserved beneath the extensive cover of glacial overburden throughout the valley portions of town. The CVS rocks are a valuable bedrock aquifer capable of high yield wells in those areas where karst has been developed and preserved. Most of rock wells in town tap into this aquifer and have a mean yield of 21GPM.

The eastern margin of town is underlain by quartzite or interbedded quartzite and conglomerate along the flanks of the Green Mountains. There are no well data here. The quartzite is a reasonably good aquifer, however, as shown by work in Wallingford, Manchester and Arlington. In Dorset, the quartzite has springs and seeps issuing from the Green Mountains flanks and this demonstrates the aquifer is useful.

Green Mountain Sequence (GMS); The higher Green Mountain elevations are thinly veneered with till and this till has weathered and allows water to infiltrate into the subsurface. Statewide, the average yield for wells in the various lithologies of these pre-Cambrian rocks of the Green Mountain Sequence (GMS) ranges from 10-15GPM. The lithologies of the higher Green Mountains generally east of the town boundary do allow water to infiltrate the fractures in the rock through the weathered till veneer. This likely contributes some of the recharge to the East Dorset Fire District springs.

Taconic Sequence (TS); The Taconic Mountain lithologies of the Taconic Sequence (TS) can be found in along the border with New York and in the Dorset Mountains. These higher Taconic Mountain elevations are underlain by slate, phyllite and thin interbedded quartzites and carbonates. The TS rocks contribute recharge through weathered fractures to the underlying rock units. Further, these high elevations contain a very thin veneer of till that may be only a foot or so thick. This thin till has weathered and become relatively permeable over time. The soils on areas of thin till with frequent rock outcrops allow water to infiltrate the shallow soil profile and some of this water can penetrate the weathered fractures and foliation in the TS rocks. Although these areas represent rock aquifer recharge zones, they are not good aquifers. The mean yield of some 2 dozen wells in TS rocks is less than half that in the CVS rocks.

Structural features; The trace of a major thrust fault is also shown and occurs along the contact between the Taconic Sequence and the underlying Champlain Valley Sequence. The value in delineating the thrust faults is that, typically, faults impact the flow of groundwater. They may pose an impermeable barrier to groundwater flow due to mineralization that often occurs along the fault zone. However, it is also possible that groundwater flow may be enhanced near fault zones due to enhanced weathering of the fractured rock of a fault zone.

Analysis of the available bedrock maps and interpretations reveals a puzzling difference in interpretation of the structural geology of Dorset. The Hydrogeologic Units map shows only one major thrust fault and is consistent with the most recent interpretations. However, if you examine the old 1961 State map you will see a second thrust fault that is most apparent where it crosses the valley south of Prentiss Pond. This fault climbs up the Dorset and Taconic Mountains on both sides of the valley where it closely parallels the higher and major Taconic thrust fault. Further, the 2 older detailed studies of the area (Shumaker and Thompson, 1967; Hewitt and LaBrake, 1961) differ in their interpretation of the major structural elements of the region. These differing interpretations illustrate the ongoing process of gathering data and learning that typifies scientific research. The most recent interpretations will be shown on a forthcoming new State bedrock geologic map and our Hydrogeologic Units map most closely agrees with this new interpretation.

Springs, Seeps & Well Locations (included on the Hydrogeologic Units Map)

Dorset contains numerous large springs along the valley flank through Dorset Valley and Mettawee Hollow. These springs are located below the Taconic thrust fault which separates the TS rocks from the underlying CVS carbonates and quartzites. The majority of the large springs in the Dorset-Mettawee Hollow area appear to be closely related to the Bascom Limestone Formation, a rock unit known to be an excellent aquifer in other portions of the State.

In addition, the contact between thin till veneer on the steep slopes generally above the thrust and thick till blanketing the gentler valley flanks below the thrust results in a topographic setting that favors seeps and spring flow. Recharge to these carbonate bedrock springs is a detailed subset of recharge potential to the bedrock aquifer as a whole.

Dorset water well data were examined in order to assess the water source to the well, the nature of the overburden, and to identify any errors in the dataset. Overburden wells were distinguished from bedrock wells and some of the initial records were changed to identify the correct water source as best determined from the well log. The data were also amended for erroneous depth to bedrock input in the original dataset due to a default method of filling in that data column; a default zero is automatically entered for the depth to bedrock in any well that does not reach bedrock – the overburden wells and any well that is re-drilled. Additional data were generated by determining the well elevation, water table elevation and bedrock elevation, all in feet above sea level. This was necessary in order to use these data to create many of the derivative map layers prepared for this report.

A total of 335 linked well records were studied. The linked well record refers to the value added step in taking the well record and matching that record to a current E-911 address. This enables the location of the well at least to the general vicinity of the house on the lot.

The yield of the wells is shown on the map by the color coding and size of the circle for each well. This may enable users of the map to casually assess where some high yielding wells and large springs are known to exist and see if any trends occur. If these data can be predictive in any manner, then, the user might hypothesize where there may be a greater chance for a high yield well based upon existing high yield well locations.

Overburden (SG) wells

Only 21 overburden wells were identified from the 335 total wells in the dataset. Most of these wells represent shallow unconfined aquifer conditions while 7 wells appear to tap into a locally confined aquifer beneath fine grained sediments described as moist blue clay, blue clay or gray clay. It is currently believed these 7 wells represent local occurrences of a fine grained sediment facies above the sand and gravel, not a widespread occurrence since no fine grained lacustrine sediment was mapped in the town. Additionally, 5 bedrock wells record buried clay beneath gravel. While several tens of feet of this clay are recorded in the logs, other nearby well logs reports no such clay. Therefore, the clay may be only locally present and the confined aquifer conditions may only be a local feature in an otherwise large, single unconfined overburden aquifer.

In addition, several of the well logs tapping the shallow unconfined aquifer record a hardpan and boulders or boulders and gravel unit. Thus, the stratigraphy of the overburden is complex. Facies changes occur over short lateral distances. Fluvial sediments of sand and gravel texture have occasional interbeds of less sorted and coarser grained sediments that may be of sediment flow, slump or even minor till. Lacustrine conditions resulted in finer grained clay and silt sediments that also may have been local in occurrence and represent former ice marginal ponds or quiet water in a formerly large ice marginal lake. The fine grained lake sediments are present beneath the upper Mettawee Valley and record the former presence of an ice marginal lake during ice retreat from the upper valley in the Upper and Lower Loop Road areas. In addition, the lake sediments are present in the main part of the Mettawee Valley down valley from the town and record the former presence of the larger glacial lake that fronted the retreating Mettawee ice northward into Rupert and farther down the valley into New York State.

The average yield of the 21 overburden wells is 43 GPM. No gravel well has a yield <15GPM nor >100GPM. The high value may be considered a minimum estimate of the yield by the driller as the same value appears 3 times in the data. The 43 GPM average yield of overburden wells is significantly higher than the average yield of overburden wells in other towns examined to date. This may be a real consequence of the geologic setting of Dorset where there are narrow valleys bordered by steep and high mountain slopes. The valleys are in filled with relatively thick accumulations of generally permeable gravel and sand sediments. The valley floors and steep slopes are also underlain by demonstrably permeable carbonate rock. Direct recharge of the overburden aquifers is easily achieved by surface water infiltration through the widely occurring permeable surface sediments. As previously discussed, there may be indirect recharge from the beds of streams flowing out of the mountains and across the permeable gravel and sand units. This water flows into the streams as runoff from high mountain slopes, ridge lines and summits.

Also, there may be a contribution of recharge from beneath the gravel as water infiltrates the permeable bedrock. The carbonate rock may recharge the gravel aquifer in those places where there is no impermeable sediment barrier between the 2 units and where the hydrostatic pressure in the bedrock aquifer is sufficiently high. This is a possibility but not one considered in preparing the map of recharge to the overburden aquifer. The extent of the overburden aquifer is delineated on the Shallow Overburden Aquifer and Recharge Map. The surface and subsurface extent of the gravel and sand sediment was taken into account in outlining the possible extent of the shallow overburden aquifer. On this map, the areas of thickest overburden sediment, >60ft thick, are shown as these areas have a greater likelihood of being to produce a high yield well due to a greater saturated thickness of permeable sediment.

The average overburden well depth is 111 ft with a range of 50-265 ft. These data suggest that drilling an overburden well in an area identified as the overburden aquifer will likely be a comparatively shallow.

Carbonate (marble, limestone, dolostone) and quartzite wells of the Champlain Valley Sequence (CVS)

The vast majority of Dorset wells tap into carbonate and lesser amounts of quartzite of the Champlain Valley Sequence (CVS). The extent of the CVS aquifer is shown on the Hydrogeologic Units Map. The carbonate units (I) are aerially extensive and cover most of the valley floors. Quartzite (Ib) occurs in the eastern portion of town and also interbedded with the carbonates. Exposures of carbonate bedrock reveal that dissolution has resulted in high secondary porosity and permeability. Karst terrain is exposed in a few locations in town and is inferred to be buried beneath the extensive cover of glacial deposits. Numerous carbonate rock springs indicate an association with karst conditions. The map also displays the major thrust fault in the town.

The average yield of the 290 CVS rock wells is 21 GPM with a range from 0-250 GPM. The CVS aquifer is primarily recharged by infiltration through areas of exposed bedrock and areas of thin till covering the summits and upper mountain slopes throughout the town as shown on the Recharge to Bedrock Aquifer Map. CVS rock wells tend to be fairly deep with an average depth of 309 ft and a range of 40-900ft. The high average yield of the CVS aquifer is notable.

Taconic Sequence (TS) wells

It was determined that 24 bedrock wells were drilled into a fine grained metamorphic rock called phyllite, slate, schist or shale in the drillers logs. Phyllite is the most prevalent Taconic type lithology in town and all 24 of these wells were lumped into the Taconic Sequence hydrogeologic unit.

The average yield of these 24 wells is 10 GPM with a range of 0-50 GPM. However, 50% of phyllite wells have a yield of ≤3 GPM while 25% of phyllite wells have a yield ≥15GPM. Furthermore, phyllite wells tend to be very deep with an average depth of 423 ft and a depth range of 140-800 ft. Thus, phyllite is not considered an aquifer but is referred to as an aquiclude in the hydrogeological sense due to its low permeability. However, if the phyllite supplies enough water to be used by a consumer, then it is that consumer's aquifer.

Green Mountain Sequence (GMS) wells

No single well tapped gneiss or granite bedrock typical of the Green Mountains summit region. However, on a statewide basis, the quartzite of the Mt. Holly Fm. has an average yield of 13 GPM and average depth of 320 ft.

Other wells

Ochre is a weathered material resting atop bedrock and there are scattered places where the advancing glacier apparently did not remove all of the old weathered material and there is ochre preserved beneath till. Only 4 wells were identified to have a water source in the ochre. These wells have an average yield of 11.3GPM. The average depth drilled is 177ft and the depth range is 85-400ft.

No logs exist for 24 other wells and these wells could not be further considered in this analysis.

Recharge Potential to Bedrock Aquifer

Recharge potential is ranked from highest, I to lowest, III. Criteria provided enable you to better understand the reasoning behind this evaluation. These criteria combine knowledge of surficial geology, overburden thickness and stratigraphy of the overburden. Recharge potentials are qualitative and no absolute values on rates of recharge through each of the surficial material types can be provided. This is especially true because of the heterogeneous nature of most surficial materials deposited in glacial environments. The Recharge Potential to Bedrock Aquifer map delineates the areas of high, moderate and low recharge potential to the marble aquifer.

I: HIGH

Thin till areas in mountain regions offer little impedance to downward infiltration due to the weathered and relatively permeable shallow soils over bedrock. These are the high elevation areas where the thin till veneer and frequent rock outcrops enable some recharge into the underlying fractures and foliation of the rock. Most prominently, these are the summit ridge lines and steep mountain flanks. The ease with which water can infiltrate the soils to the underlying rock in areas of till is dependent upon how weathered and how thin is this till veneer. On the high elevation slopes, ridge lines and mountain summits, the till is typically a very thin veneer, often less than 1 foot, typically less than 3 ft. While unweathered till is dense and impermeable, the soils that develop on very thin till veneer allow relatively easy infiltration of water through the thin soil into the rock. Exposed rock has had a long time to weather since the retreat of the glaciers and fractures have opened to allow surface water to infiltrate the rock in the high mountain elevations. This is the reasoning behind the traditional and accepted view of high mountain areas serving as major recharge zones to rock aquifers in the adjacent valleys.

Typically, the contact between thick till and thin till may be recognizable in the field by the occurrence of seeps or occasional springs. The groundwater flowing at shallow depth cannot penetrate deeper and may flow out onto the surface in these contact areas where there is a flattening of the land. This lower elevation boundary between thin till and thick till can often be seen in the field as a place of seepage where shallow groundwater and, possibly, deeper groundwater, may emerge again to the surface.

II: MODERATE

Areas of permeable surface sediment may be partly or wholly in contact with bedrock and this facilitates recharge of the bedrock aquifer. These are the areas of ice contact, outwash and inwash sediments dominated by gravel and sand. On the surficial map, these are identified as Qkm, Qkt, Qk, Qe, Qow, Qiw, and Qif.

Enhanced areas of such recharge may occur where there is a stream flowing across permeable gravel and sand and this stream is losing water through its bed to the subsurface. However, this is a hydrologic setting that must be verified and not presumed to exist wherever there is a stream. To a lesser extent, areas of ground moraine may be locally permeable and contribute significant recharge to the underlying rock. There is uncertainty in that some areas of surficial deposits *may* in any given specific site be underlain by relatively impermeable till. Only site specific investigations can answer this question.

III: LOW

Areas of impermeable thick till do not easily allow water to penetrate any deeper than the base of the soil profile. These occur along the lower mountain flanks in areas where there are no permeable surficial deposits and where thick till blankets lower valley ridges.

Where there is thick till mantling the Taconic and Green Mountains lithologies, there is a comparatively thick and relatively impermeable barrier to the infiltration of groundwater through the till into the underlying bedrock. Till is an impermeable sediment and even though the upper surface of the till has weathered and has a more permeable soil developed upon it, beneath the soil there is dense, impermeable unweathered till. Thus, thick till areas are not places where the underlying rock can be easily recharged.

Wetlands, typically places of groundwater discharge to the surface, do not serve to recharge the underlying rock aquifer.

Potentiometric Surface Map and Groundwater Flow Lines

The elevation of the static water level in bedrock wells reported in the well log data was determined and these elevations were contoured on the Potentiometric Surface and Groundwater Flow Lines map. The static level of water in a well is a useful parameter as it is a factor in determining the amount of water that is stored in the well bore, and thus, available to be pumped into a house or other structure using the water. These data were contoured using a 100ft contour interval only in the valley portions of the town where there were a sufficient number of wells. The contoured map shows the typical pattern of static levels that mimic the underlying topography. It must be remembered that the reported static level for a well may be unreliable if the measurement was made before a well had completely recovered from pumping; such isolated low values of static level were discounted in the construction of the map.

Groundwater flows down the hydraulic gradient from a high potentiometric level to a low potentiometric level. Flow lines drawn on a potentiometric surface map are at right angles to the potentiometric contours. Notice the groundwater flow lines reveal the general path of groundwater flow from regions of higher potential to regions of lower potential. The potentiometric surface map and the accompanying flow lines enable us to visualize the directions or pathways of recharge from higher regions in an aquifer to regions of discharge in lower portions of an aquifer.

Recommendations

There are numerous occurrences of overburden wells with yields in ranges suitable to serve communities. A further detailed investigation of the potential for overburden aquifers to serve as possible water sources should be done. The selection process of a single or of multiple sites for further study is warranted as the data indicate very strong potential for valuable overburden aquifers in the town.

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