**Proposed Site for New Well**
**Sterling, New York**

**December 7, 2020**

## INTRODUCTION

The Town of Sterling, New York, wants to develop an additional supply well at its wellfield on the south side of Route 104A, one mile east of Fair Haven (Figure 1). The Town already has two supply wells at this property. Working with its consulting engineer, C2AE, the Town retained HydroSource Associates (HSA) to help assess the site and identify potential locations for developing an additional well on the property.

HSA's scope of work for this project included an initial evaluation of available background information on hydrogeology. This was followed by geophysical surveys intended to appraise the subsurface conditions and identify where thick sequences of saturated coarse-grained sand and gravel may be present. HSA was to identify potential well sites based on the resulting information. In addition to favorable sediment characteristics, other site selection characteristics taken into consideration included maximizing offset distance from the other supply wells to minimize hydraulic interference between wells, and satisfying the setback requirements of the New York State Department of Health (NYSDOH) to the degree feasible given the limitations posed by the size and configuration of the property.

## HYDROGEOLOGIC EVALUATION

### Bedrock Geology

A published geologic map shows that the area including the Sterling wellfield is underlain by sedimentary rock of the Grimsby Formation (Isachsen & Fisher, 1970). The following description is based on information from an online U. S. Geological Survey stratigraphic database (USGS, 2020). The Grimsby Formation consists of interbedded red and green sandstone, siltstone, and shale, and is a member of the Medina Group of Early Silurian age. A phosphate-rich bed occurs near the base of the Grimsby, and the basal five to ten feet of the formation typically consists of greenish-gray and maroon shale. The lower part of the formation tends to be fossiliferous. Higher parts of the unit consist of red and white mottled fine-grained to medium-grained sandstone and conglomerate interbedded with shale. The formation's thickness ranges from 56 to 72 feet.

The sedimentary sequence that includes the Grimsby is flat-lying and undeformed in this area. Taking that into account, it appears likely that the bedrock surface on which the younger glacial sediments of the area were deposited has a generally flat, table-like form, similar to the orientation of bedding planes in the sedimentary rock itself. However, that flat bedrock surface may be interrupted at least occasionally by glacially deepened troughs.

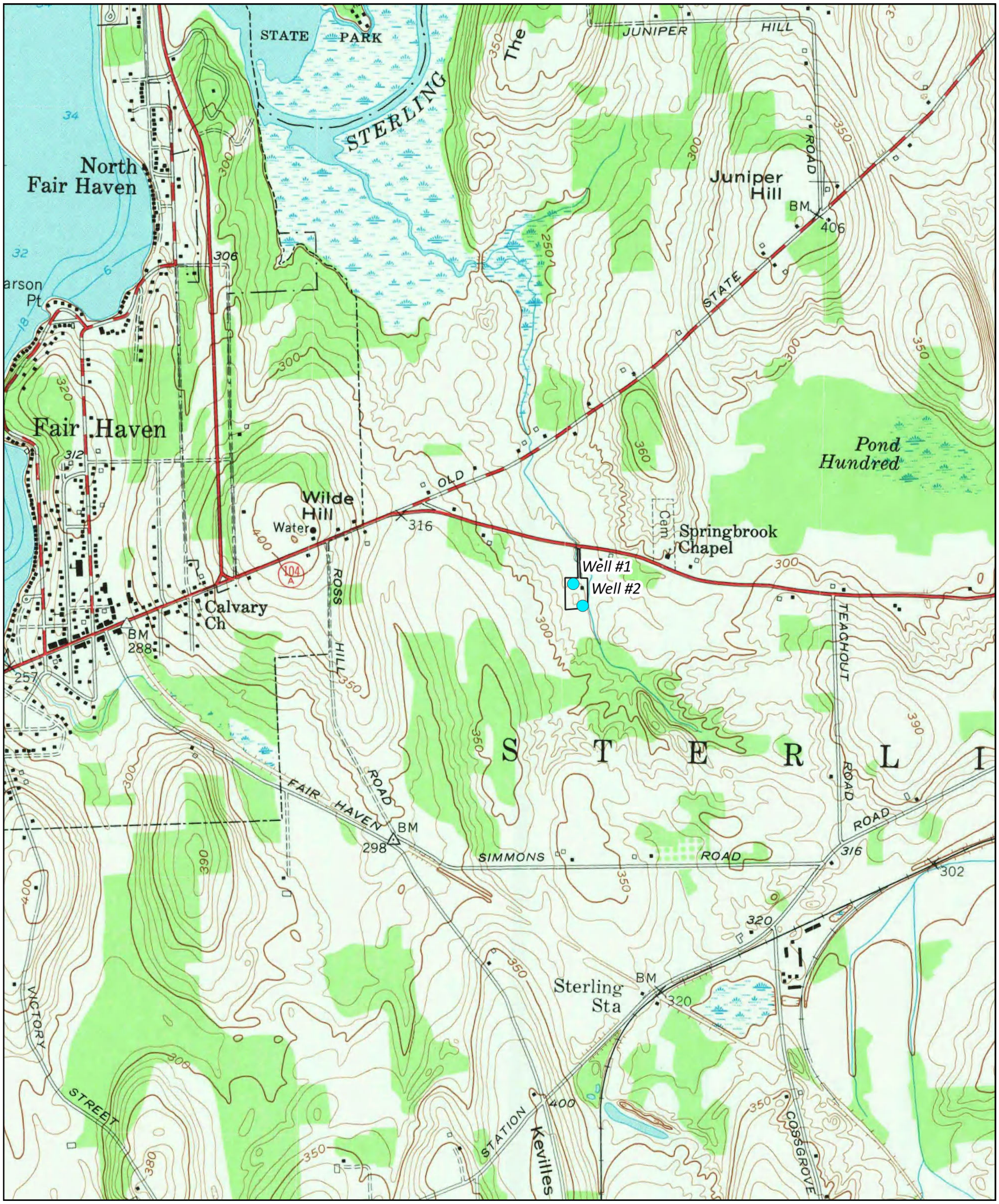



**Figure 1 - Wellfield Location**

## Surficial Geology

Information on the surficial geology of the area including the wellfield comes from recent quadrangle-scale mapping (Bird & Kozlowski, 2015). Figure 2 is a surficial geologic map. Bedrock is covered by a relatively thin layer of glacially derived sediments.

Glacial till is exposed at the higher elevations. Till consists of poorly sorted sediments, having grain sizes ranging from clay-sized to boulder-sized. On the map it is shown in gray. The material is described in the map legend as "diamicton," which is the preferred technical term for this type of sediment. The material making up the till was derived from the bedrock surface as the glacial ice flowed into this area from the northwest. The rock was ground up in and beneath the moving ice, producing a mixture of boulders, sand, and rock flour, and the disorganized sediment was left in place when the ice melted.

The movement of the ice contoured the ground surface, leaving behind a longitudinal grain in the topography. The many low elongate hills near the wellfield are drumlins, made out of mounded-up till. The drumlins near the Town's wellfield show a northerly or north-northwesterly direction of elongation, which indicates that the ice moved across the region from NNW to SSE. The till thickness can be as much as 100 feet in some of the drumlins.

Melting of the ice during the glacier's retreat produced large volumes of meltwater, and the resulting high-volume meltwater streams left behind substantial volumes of permeable sand and gravel. At some point during the glacial retreat, the ice margin stalled for a time at a location about a half-mile southeast of the wellfield (Figure 2, line of red dots). At this time, a fast-moving southeast-flowing meltwater stream must have developed in an ice tunnel in the region between the wellfield and the ice margin. This stream left behind an esker, which is a stringlike body of well-sorted sand and gravel (included in the area marked Psg on Figure 2). Presumably, at least one of the Town's existing wells taps sediments associated with this esker. Although Figure 2 shows the esker as terminating just south of the wellfield, it is possible that additional esker sediments persist for some distance to the north.

An outwash fan developed in the area just south of the ice margin. The water of the meltwater river that left behind the stringlike esker deposit, where its course was confined in the ice tunnel, was able to spread out over a broad area after it flowed out beyond the edge of the ice. It dumped a large load of sediment in a fan-shaped deposit along the ice margin.

The sediment of the esker and the outwash fan was deposited during a brief interruption in the glacier's retreat, when the ice margin was stationary. After the retreat resumed, and the edge of the ice moved further north, the area was partly submerged beneath a glacial lake. This lake, called Lake Algonquin, covered much of the low-lying area around the Great Lakes in the whole region northwest of the Adirondacks.

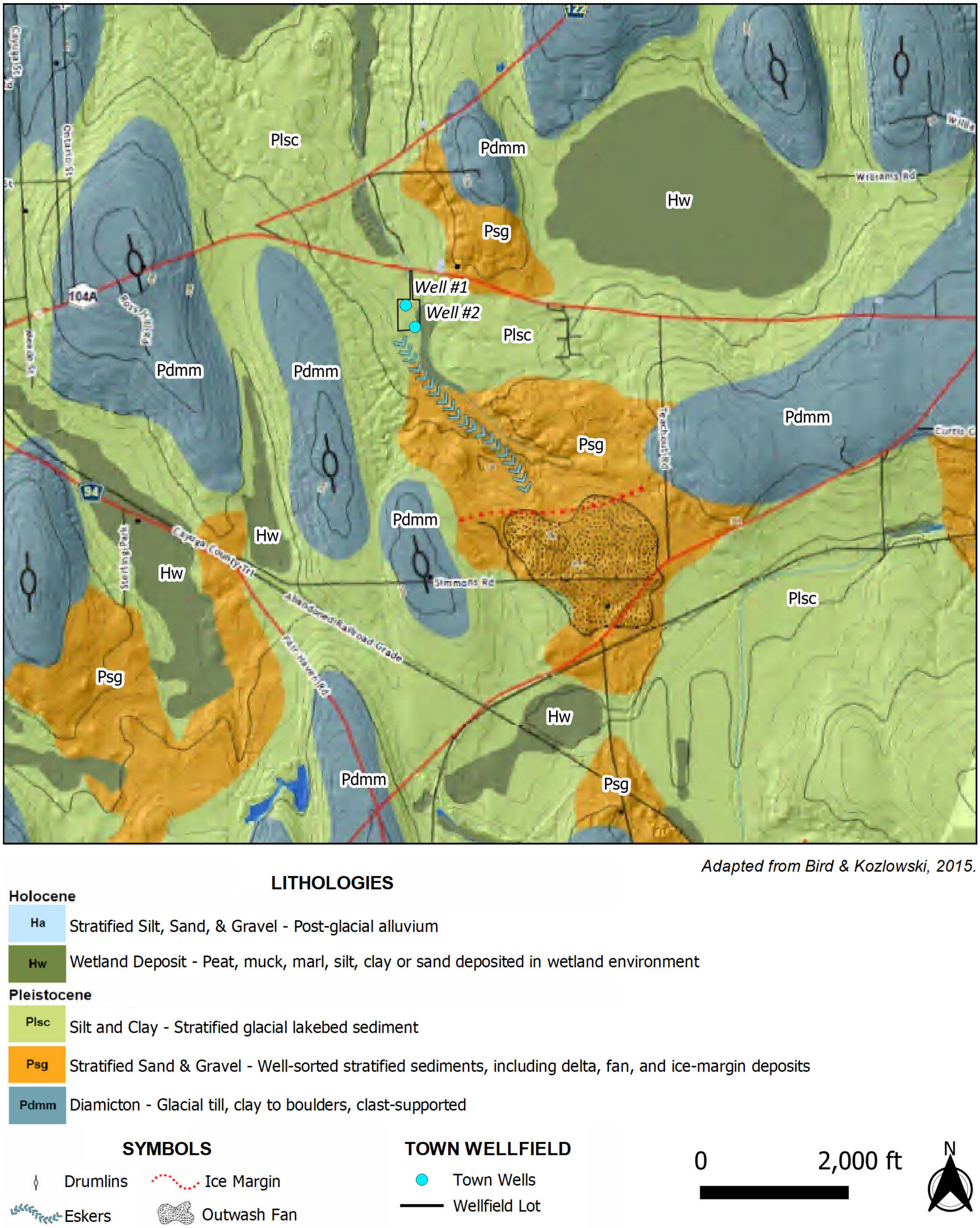



**Figure 2 - Surficial Geology**

The meltwater carried a heavy load of fine-grained sediments that slowly rained out of the quiet water of the lake. This resulted in a layer of lakebed sand, silt, and clay (Plsc on the map) being deposited at the lower elevations that were flooded by the lake. During the period when the lake occupied this area, the drumlins of till stood up as islands, as did some of the areas of coarse-grained sand and gravel. The 1967 driller's log of the Town's Well #1 shows that the productive gravel at this site was covered by about 20 feet of this fine-grained lakebed sediment (clay in this case). It is likely that substantial thicknesses of productive sand and gravel are hidden beneath lakebed sediments at many other nearby locations.

The sediments described above are of Pleistocene age, meaning that they were deposited during the last glaciation. Holocene sediments are those deposited after the end of the glaciation. These include sand and gravel deposits laid down along the course of post-glacial streams, though no such deposits appear in the map view of Figure 2. The other category of Holocene sediments is wetland deposits, represented most prominently by the large peat bog northeast of the wellfield.

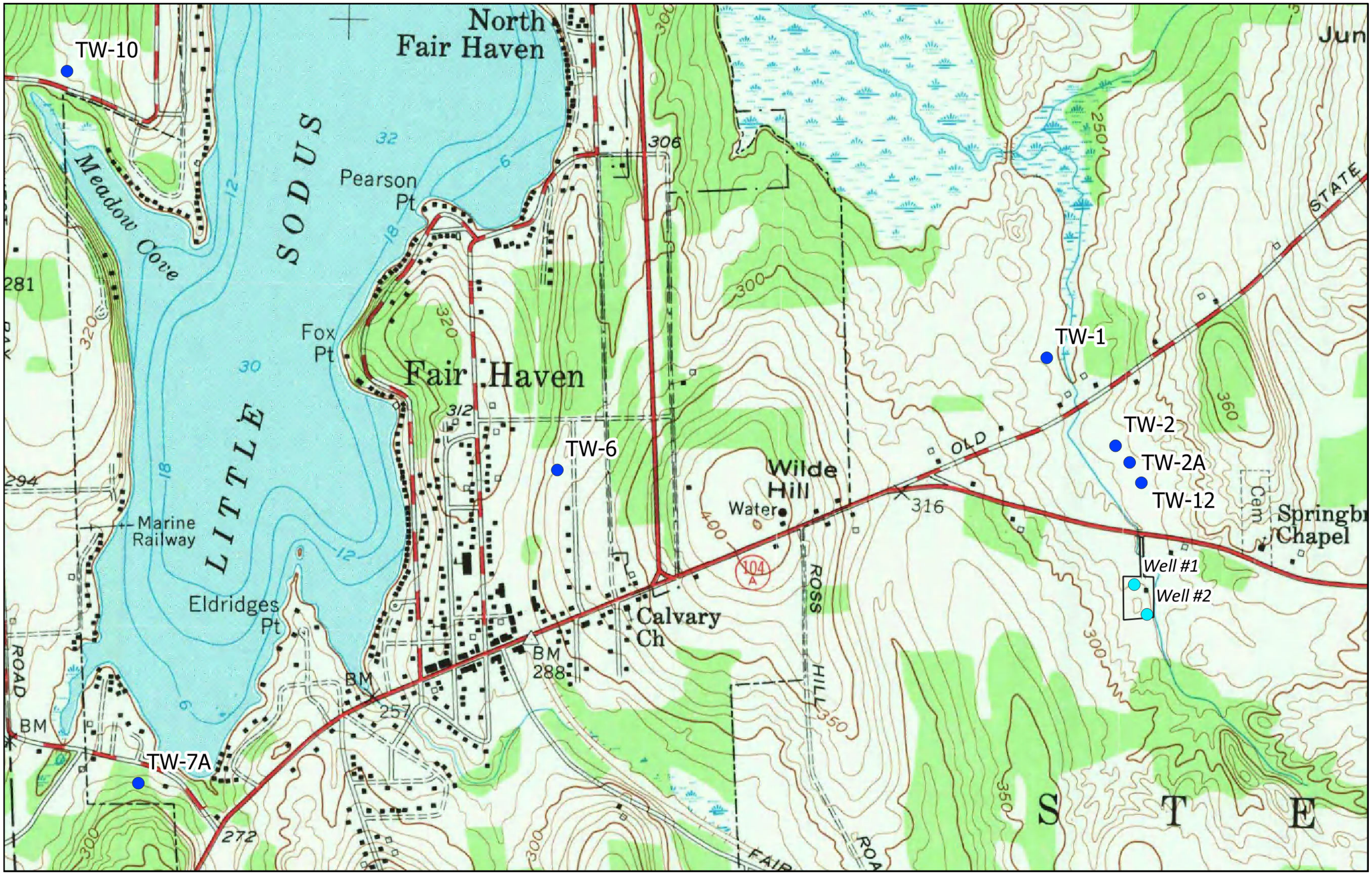
**1967 Well Drilling and Aquifer Testing**

HSA examined drilling records it was able to obtain from the Town's 1967 efforts to develop a new water source, in case information produced by the prior work might be useful in the current project. The 1967 work included drilling of a series of test wells, with short-term pumping tests conducted on a few of the more promising wells. Layne-New York (now Layne Christensen) conducted the drilling and testing, and the available documentation consists of Layne driller's logs and pumping test data sheets.

The Layne documents do not include maps showing well locations, but they do include cryptic notations describing the locations of the individual wells. Figures 3 and 4 shows the locations of the wells that we concluded we could locate with reasonable accuracy. Although we believe the locations are generally accurate, and are consistent with the driller's notes, it is likely that in some cases the locations we show on the maps may be offset a considerable distance from the true well locations.

Based on the Layne documents, it appears that two supply wells may have already existed and were in use when the test drilling was being done in 1967. The notes contain references to "the water plant" and "the pump station" that presumably refer to facilities already in existence at the property. Overall, the documents indicate that the Town may have been attempting to find alternate sites to the existing wellfield in 1967, but they do not include any explanation of why the search was undertaken.

The Layne documentation of the 1967 effort includes records on the construction and brief testing of one large-diameter well. This appears to be the well currently known as Well #1, which may have been drilled as a replacement for an older well that had been constructed years earlier when a wellfield was first established at the site. For the record, details on this well from the Layne documents are summarized in the following paragraphs.




**TOWN WELLFIELD**

- 1967 Test Wells
- Town Wells
- Wellfield Lot

0 1,500 ft

N

**Figure 3 - 1967 Test Wells, Wide View**


**Figure 4 - 1967 Test Wells, Wellfield Closeup**

The well was drilled between June 1 and June 8, 1967. It is described as a 22x18x12 well, with a total depth of 46 feet. It hit "boulders, sand & gravel, medium to coarse" from 21 to 24 feet, and "gravel & sand" from 24 to 46 feet. The driller's report states that the well has 10 feet of screen, but the slot size is not provided.

The notes include records from an eight-hour pumping test that was conducted on Well #1 shortly after it was completed. The notations refer to a "village well" (apparently the older well referenced above), and mark the times during the Well #1 test when the village well pump was running, and again when the pump stopped.

The pumping test data shows that operation of the village well caused drawdown of a little more than one foot at Well #1. The data sheet also includes water levels from one observation well, labeled "dug well" on the sheet. The dug well shows 2.5 feet of drawdown in response to pumping of the village well. The data sheet gives the distance between the dug well and Well #1 as 25.5 feet. Because the dug well shows a bigger response to pumping of the village well than Well #1 does, it may be inferred that the village well is closer to the dug well than to Well #1.

### 2016 and 2019 Layne Well Redevelopment and Pumping Tests

Layne carried out well maintenance and redevelopment work in 2016 and 2019, and pumping tests done as part of these efforts give information on the relative productivity of Well #1 and Well #2. During a brief 2019 post-development test of Well #1 at a rate of 339 gallons per minute (gpm), the well showed drawdown of about 1.5 feet and a specific capacity of 225 gpm/ft. A similar post-development test of Well #2 in 2016, when the well was pumped at 183 gpm, showed drawdown of about nine feet and a specific capacity of 20 gpm/ft. Well #1 is significantly more productive than Well #2, which in general would suggest that the hydrogeologic conditions relevant to productive well development are likely to be better at or near the location of Well 1.

## GEOPHYSICAL SURVEYS & PROPOSED TEST WELL LOCATIONS

Resistivity surveys were run along two survey lines crossing the wellfield property in November 2020. Both lines were 300 meters long (Figure 5). Per C2AE's request, the lines were sited in a manner intended to provide geophysical coverage over much of the southwest quadrant of the property. The positioning of the lines also considered the property configuration and site conditions, the orientations of the presumed bedrock trough and bodies of permeable sand and gravel, and the location where a new large-diameter well could most likely be sited with acceptable hydraulic interference on either of the existing supply wells.

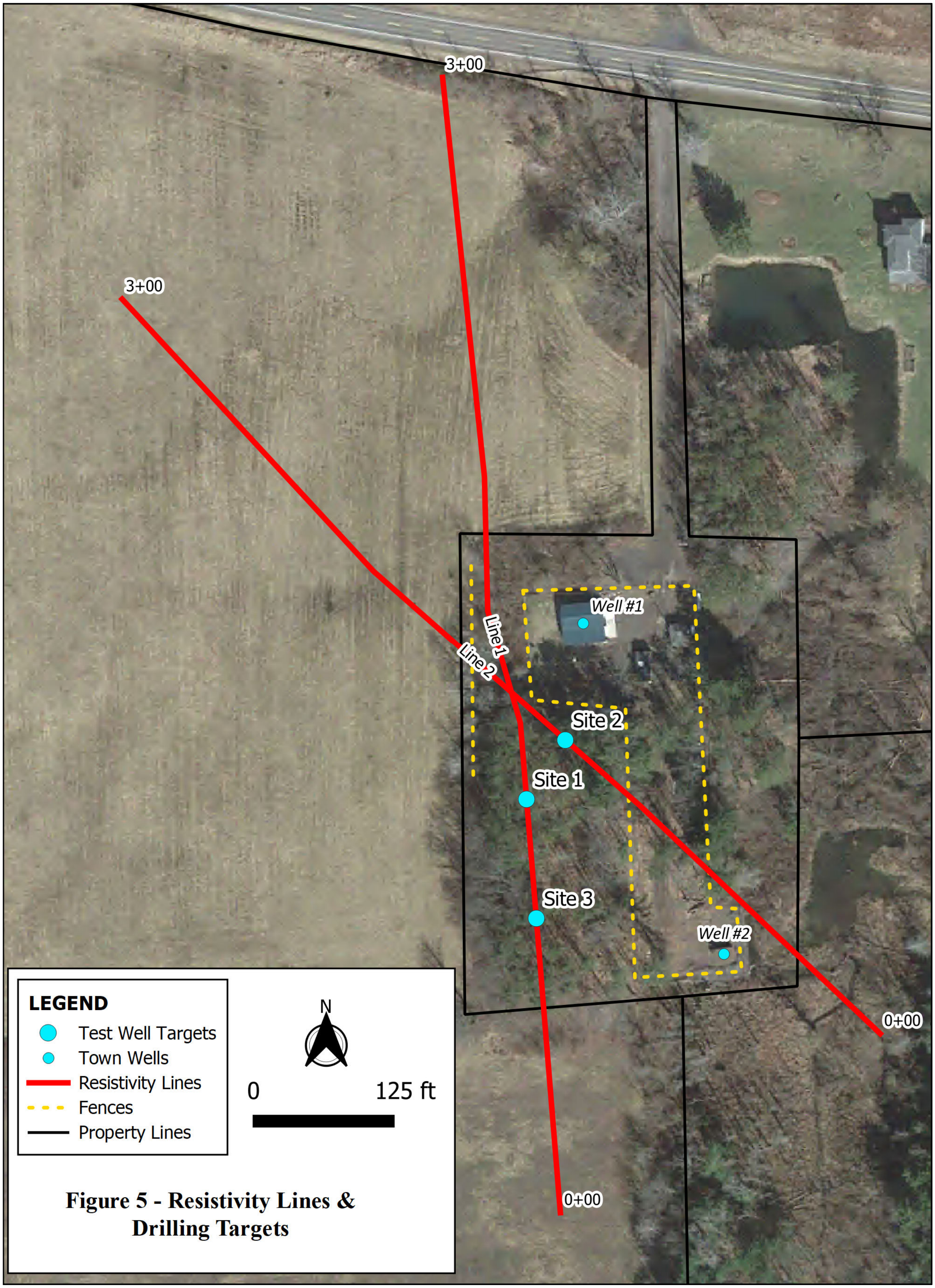



**Figure 5 - Resistivity Lines & Drilling Targets**

The resistivity lines were extended beyond the boundaries of the Town property onto the neighboring properties to allow greater assessment depth on the wellfield property itself. This was necessary because the resistivity method can achieve maximum penetration only in the central parts of the survey line. Penetration depth is lower near the line ends.

Resistivity surveys show the variation of electrical resistivity with depth along the survey line. Because different sediment and rock types can tend to display predictable ranges of electrical resistivity, the surveys can be used to assess the potential thickness and lateral extent of sand-and-gravel layers, and to estimate how far they may extend below the water table.

Figures 6 and 7 are the resistivity profiles along Lines 1 and 2, respectively. The north end of Line 1 is on the right side of Figure 6. The northwest end of Line 2 is on the right side of Figure 7. A color-code key in the lower-right corner of both diagrams shows the correspondence between electrical resistivity measured in ohm-meters and color in the profiles.

Both profiles show the horizontal distance from the line's zero point in meters on the scale that runs along the ground surface. The distance in feet is shown on the scales along the top and bottom edges of the diagrams. The profiles have no vertical exaggeration; the horizontal scale is the same as the vertical. Annotations above ground surface on both diagrams describe surface features like fences and hayfields. The annotations also include the locations of three possible sites for test wells, two of them on Line 1 and the third on Line 2. These locations are also shown on Figure 5.

The portion of Line 1 falling on the Town wellfield property runs from about 60 to 190 meters (Figure 5, Figure 6). Within that area, there is an irregular region of resistivity ranging from 200 to 600 ohm-meters whose base is at a depth of around 50 to 70 feet. This depth matches the bottom of the productive sand-and-gravel layer in the Town's existing supply wells reasonably well, and the indicated resistivities are in the right range for sand-and-gravel deposits. Therefore, it would not be surprising if this region represents the productive sediment layer that is tapped by the existing wells.

A thin layer of low resistivity runs along the surface for most of the length of Line 1, and is shown in shades of blue. Resistivity in this range often corresponds with fine-grained sediments like the clay and silt deposited on the floor of a glacial lake, and the profile shows a relatively uniform thickness of this layer, which would be typical of sediments deposited in a glacial lakebed environment. This is consistent with both the mapped geology and the logs from prior wells. The clay and silt layer is interrupted by higher-resistivity material from 40 meters to 100 meters along the line, perhaps indicating that the gravel comes closer to the surface in that area. Note also that the higher resistivity layer (in orange and yellow) is abruptly interrupted at the 55-meter mark, which corresponds with an old fence. The fence is an electrical conductor. It is contributing "noise" to the resistivity signal, and in this area is preventing an accurate reading of the variation of resistivity with depth.

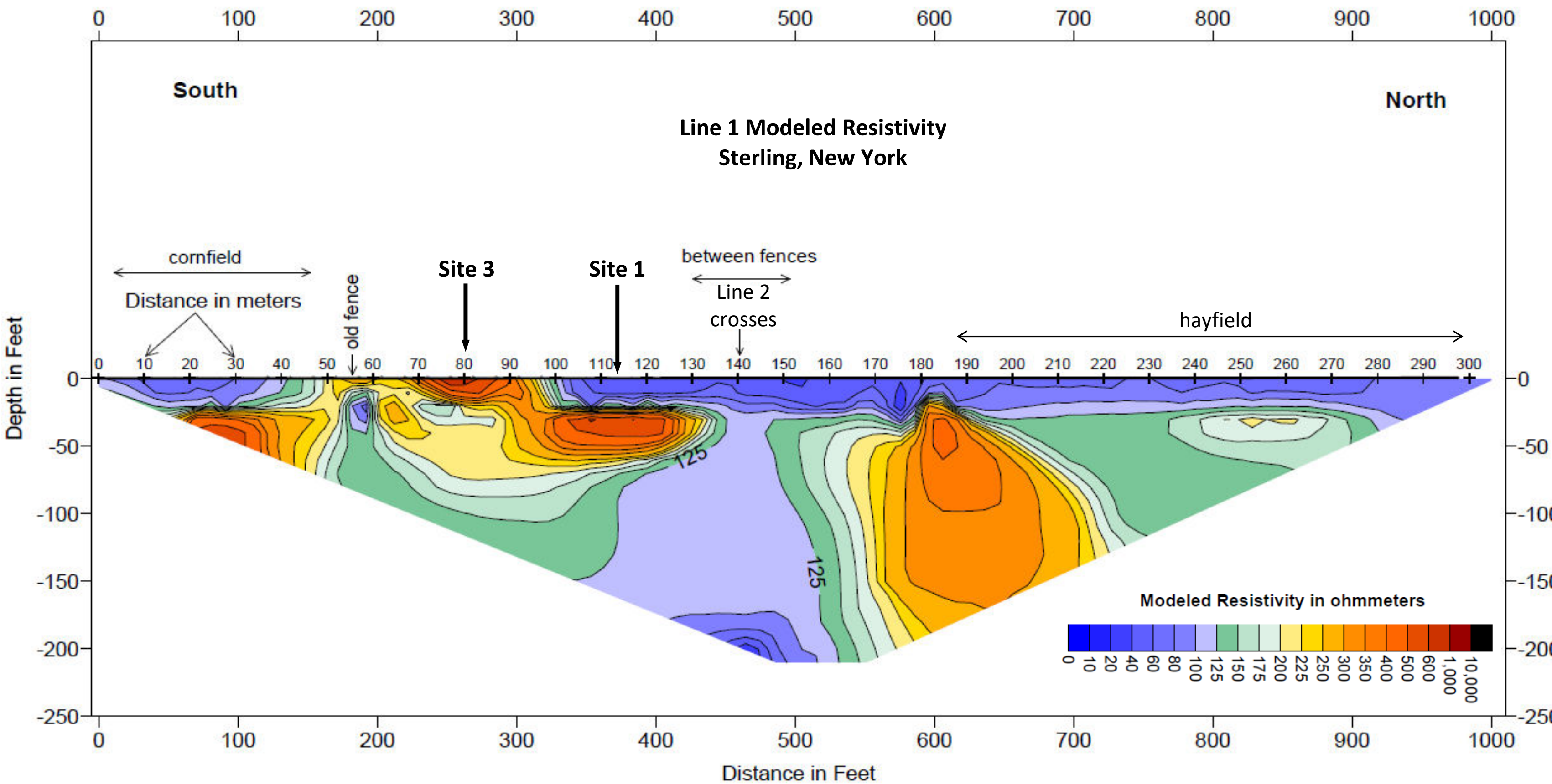



**Figure 6 - Line 1 Resistivity Profile**

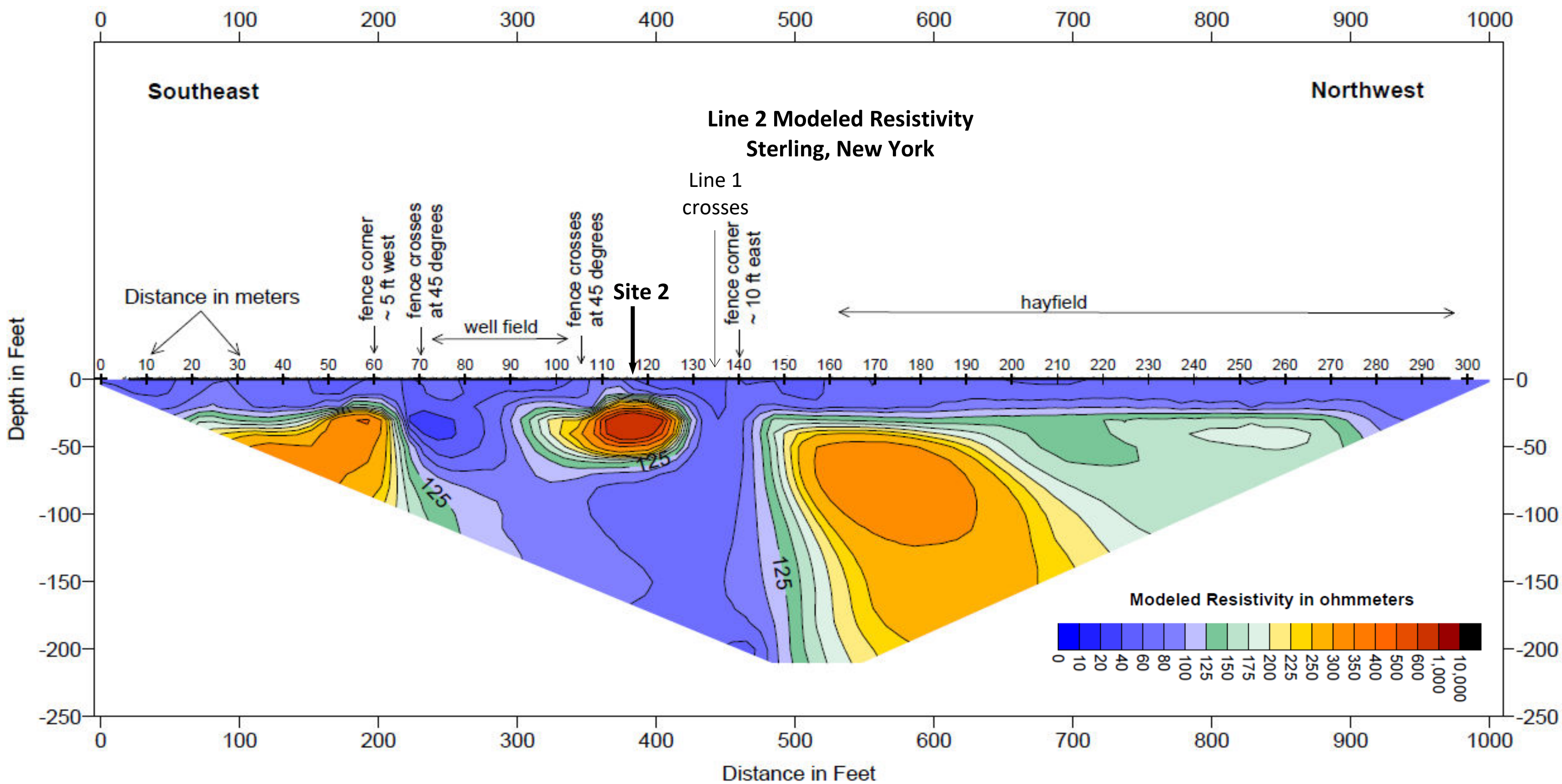



**Figure 7 - Line 2 Resistivity Profile**

Note also that there is a prominent resistivity change near the midpoint of Line 1. A region of generally low resistivity (shown in blue) occupies the entire thickness of the profile from about 130 to 150 meters. To the north of that is a block of consistently higher resistivity that extends to within 50 feet of the ground surface. The block's upper surface is remarkably flat, and this might mean that a horizontal shelf of bedrock underlies the hayfield at a depth of 50 feet. That shelf might start at the midpoint of the line, and it is possible that the depth to bedrock is somewhat deeper to the south, and that the region at the midpoint of the line represents a bedrock trough. In that case, the more-limited zones of higher resistivity centered at 25 meters, 80 meters, and 112 meters could be gravel lenses within larger volumes of somewhat finer-grained sediments. It is on the basis of this interpretation that Sites 1 and 3 have been selected as possible test well sites (Figure 6).

Site 1 is in our opinion the most promising of the three recommended test well sites. A well at this site might be expected to pass through 20 feet of fine-grained lakebed sediment before entering a layer of sand and gravel. The bottom of this layer could be expected at a depth of around 50 feet. Also, Site 1 is offset by about the same distance from Well #1 and Well #2. Its location and greater offset distance may help to minimize hydraulic interference with either existing well while also remaining on the Town-owned property.

Sediments showing the highest resistivities don't extend as deep at Site 3 as they do at Site 1. However, it must be kept in mind that the resistivity patterns do not correspond precisely with sediment distributions. This is partly because electrical interference from features like the fence at 55 meters can produce distortions in the resistivity pattern for some distance from the source of the interference. Thus our opinion is that Site 3 should still be considered a serious target.

The pattern seen on Line 2 is similar to the one seen on Line 1 (Figure 7, Figure 6). On Line 2, the thin blue near-surface layer that we believe marks fine-grained lakebed sediments extends uniformly across the entire length of the profile. A block-like zone of higher resistivity occupies the northwest half of the diagram, and the southeast edge of this block is abrupt and steep. This could mean that the high-resistivity area beneath the hayfield is a block of bedrock with a flat top surface, and that it is bordered to the southeast by a bedrock trough. Although that may be so, we doubt that the trough is as deep as the profile suggests.

In the portion of the southeastern half of the cross section on the Town property, a lens of high-resistivity material can be seen (shades of yellow and orange), at a depth of 20 to 50 feet, between the 100-meter and 125-meter marks on the line. Site 2 has been chosen to target the center of the highest-resistivity part of this zone, at the 117-meter mark on the line. This target is essentially similar to Site 1, and in fact both sites probably target extensions of the same gravel lens. Site 2 is closer to Well #1 than Site 1, and would be expected to show more interference.

It was noted in the section on surficial geology that recent mappers traced an esker segment to a point just south of the wellfield property (Figure 2). An alternate hypothesis for the prominent higher-resistivity zones north of the midpoint of both profiles is that they represent the continuation of that esker into an area where it has been hidden under lakebed sediments. That is, the prominent high-resistivity "bullseyes" at 185 meters on Line 1 and at 170 meters on Line 2 could mark a zone of esker sand and gravel. We mention this as one possibility, but the overall resistivity pattern seems more suggestive of a block of bedrock.

## CONCLUSIONS

Three potential test well sites have been identified. We propose that the Town install test wells at one or more of them, ideally starting with Site 1. If the first test well appears to be sufficiently successful to warrant development of a production well at that location, the Town could opt to move ahead with plans for developing a large-diameter well beside it. Another option would be to test one or both of the remaining sites to determine if better conditions for developing a more productive well may be present there. Whatever choices are made, the collected information, including observations made during drilling of test wells, should be reviewed as work proceeds to provide guidance on deciding whether and which test well locations should be drilled, or possibly another site chosen, after re-interpretation of all the available evidence is performed.

## REFERENCES

Bird, B. C., and A. L. Kozlowski, 2015. Surficial Geology of the Fair Haven 7.5-Minute Quadrangle, Cayuga and Wayne Counties, New York. Map & Chart Series 83, New York State Museum.

Isachsen, Y.W., & D.W. Fisher, 1970. Geological Map of New York - Finger Lakes Sheet. Map & Chart Series 15, New York State Museum.

U. S. Geological Survey, 2020. Mineral Resources Online Spatial Data database (mrdata.usgs.gov).