Hydrology and Land Use Considerations for Protecting Recharge Pathways to the Beaver Kill Aquifer

Prepared for:
Catskill Mountainkeeper
June 2022

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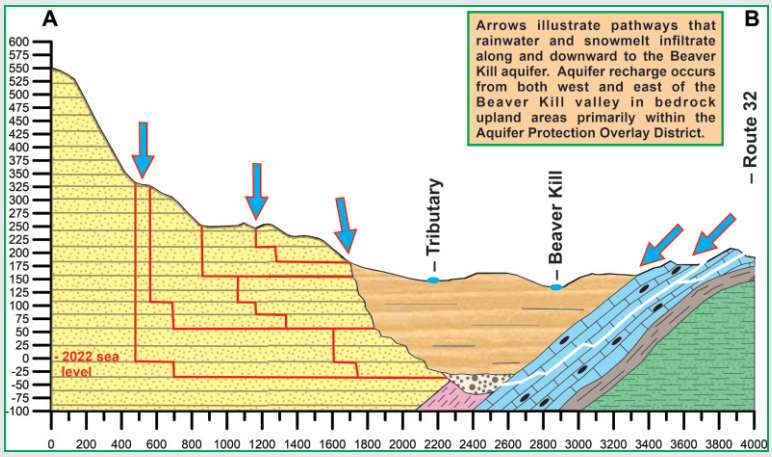

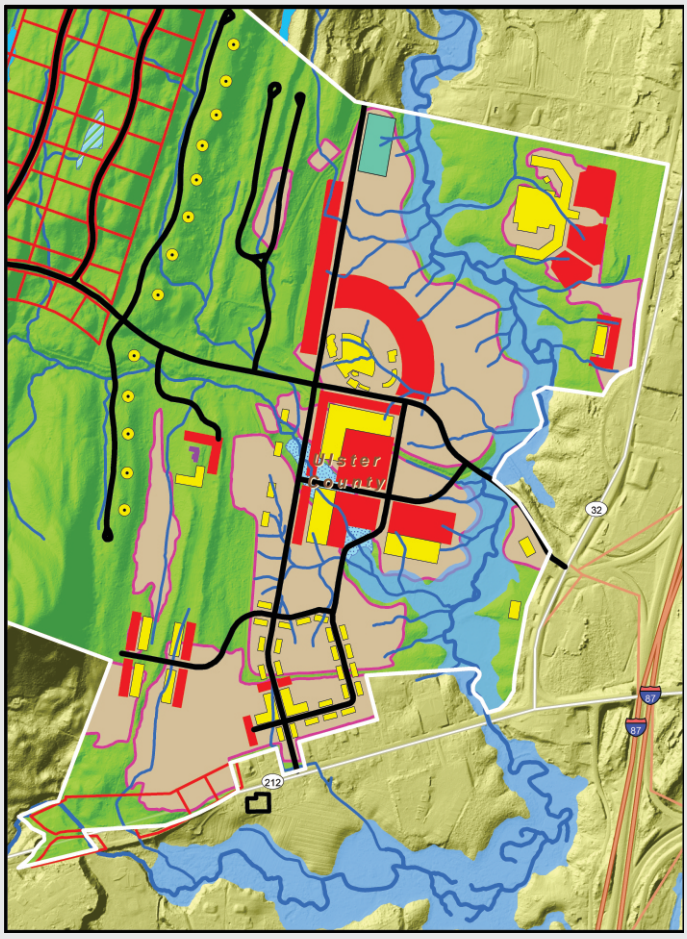

Proposed Development Over Winston Farm Fields and Upland Recharge Area

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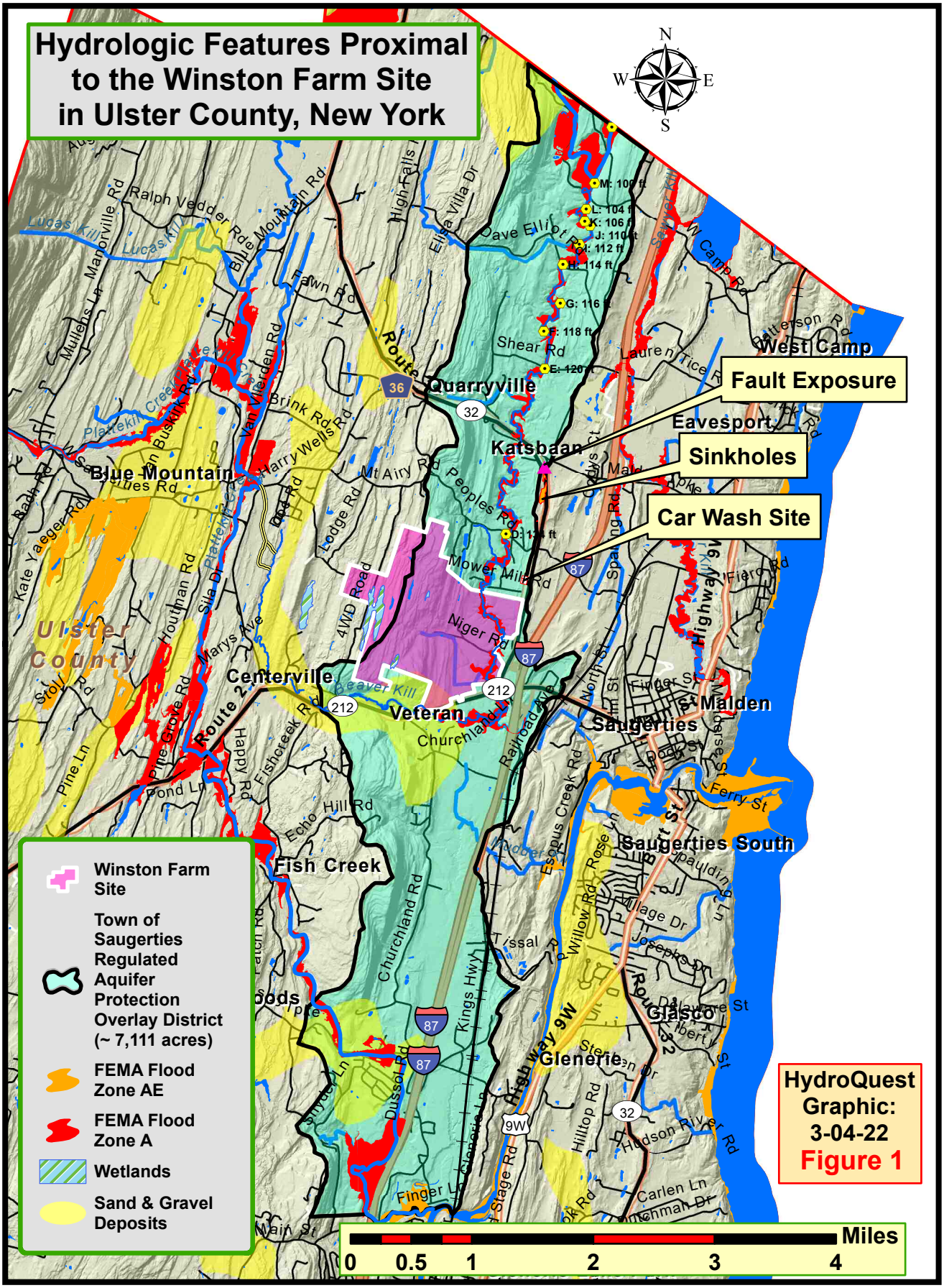
Hydrology and Land Use on and Proximal to the Saugerties Aquifer Protection Overlay District; Saugerties, NY

Introduction

Proposed development in Saugerties, New York, includes a commercial car wash and the 818±-acre Winston Farm site, which envisions development of a water park; technology and business park; commercial development; single-family, multi-family, and estate housing units; boutique hotel; adventure park resort; campgrounds; cabins; event center; and wastewater treatment plant. Figure 1 shows the Winston Farm site where the Woodstock '94 Music and Arts Festival was held, the car wash site, and surrounding area. Note that all of the car wash site and most of the Winston Farm site overlie the Town of Saugerties' regulated Aquifer Protection Overlay District (teal-colored area) which is the subject of much of this report. This report, commissioned by the Catskill Mountainkeeper, is a companion report to a January 8, 2022 HydroQuest report commissioned by the Town of Saugerties titled: *Ground Water/Aquifer Protection in the Town of Saugerties*. Here, substantial new geologic and hydrologic information is used to characterize the nature, extent, and recharge features specific to the Beaver Kill Aquifer situated beneath the Beaver Kill Valley (aka Bakoven Valley).

HydroQuest has evaluated potential environmental concerns with emphasis on hydrology, geology, and land use. Project review entailed analysis of multiple years of high-resolution orthoimagery, topography using two-foot LiDAR-derived elevation contours, published geologic reports and maps, a June 28, 2018 LBG report on groundwater exploration on the Winston Farm Property, the Town of Saugerties' Comprehensive Plan, a 1994 Hanson well driller's log from a Winston Farm well, old landfill siting studies with subsurface geologic data, NYSDEC well log data, unpublished pre-2000 drillers' well logs, area field reconnaissance, and review of the proposed development plans for the proposed car wash and Winston Farm. Material from these sources was synthesized, analyzed, interpreted, and graphically portrayed. Findings were considered within the context of the environmental review of both proposed projects, including SEQRA, Full Environmental Assessment Form (FEAF), Part 2 (Identification of Potential Project Impacts), and other information that is designed to help lead agencies inventory all potential resources that could be affected by a proposed project or action.

The material presented in this report can be used to help identify issues for inclusion in the environmental review of the proposed projects. As such, the proposed development projects should undergo a full SEQRA review, inclusive of an alternate option analysis because of the importance of the aquifer to the community and the need to protect it.


Hydrologic Features Proximal to the Winston Farm Site in Ulster County, New York
N
W
E
S
Fault Exposure
Sinkholes
Car Wash Site
Quarryville
Katsbaan
Eavesport
West Camp
Blue Mountain
Centerville
Veteran
Fish Creek
Saugerties
Saugerties South
Glasco
Glenerie
Malden
Ulster County
Route 32
Route 212
Route 2
Route 9W
Highway 9W
Winston Farm Site
Town of Saugerties Regulated Aquifer Protection Overlay District (~ 7,111 acres)
FEMA Flood Zone AE
FEMA Flood Zone A
Wetlands
Sand & Gravel Deposits
Miles
0
0.5
1
2
3
4
HydroQuest Graphic: 3-04-22
Figure 1

Former Congressman Maurice D. Hinchey (October 11, 1994), for example, sought to have Winston Farm placed on the National Register of Historic Places "… *to see that the Winston Farm receive the recognition it deserves as a place rich in history and cultural significance.*" In a letter to the NYS Office of Parks, Recreation and Historic Preservation (October 4, 1994), Hinchey stated: "… *appropriate federal recognition would acknowledge the properties' historic, cultural and agricultural significance.*" Site preservation is compatible with the Town of Saugerties' 2021 Comprehensive Plan update Goal #5.1 that envisions the Town and Village "*Work to identify, protect, and restore their historic buildings, sites, and roadside cultural features, and ensure new development respects historic traditions*." Withholding a proposed zone change that seeks to allow car washes in the General Business District and a proposed amendment to remove car washes from the list of prohibited uses in the Aquifer Protection Overlay District would support preservation of the existing regulations for the Town of Saugerties' Aquifer Protection Overlay District.

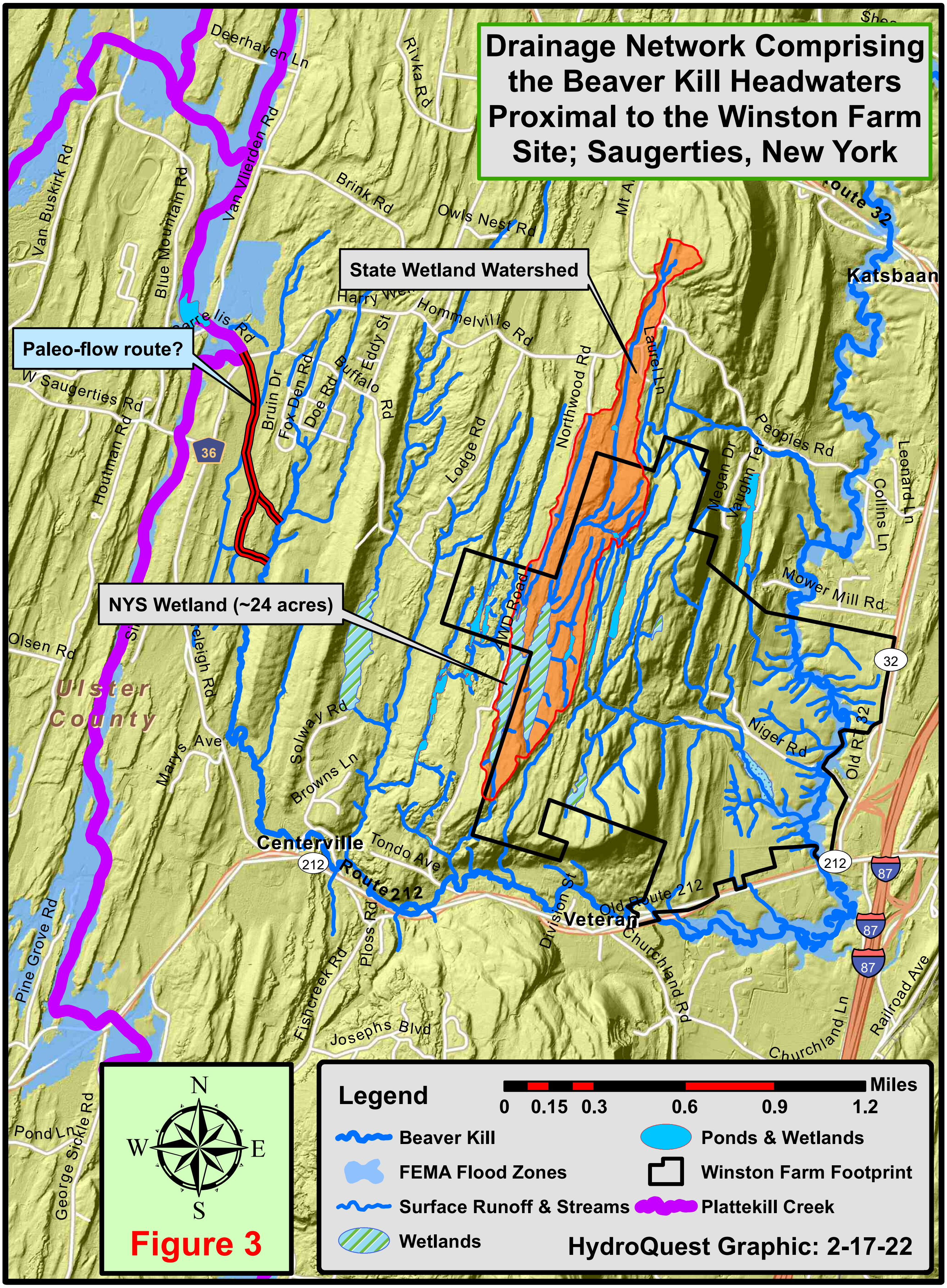
Surface Hydrology, Wildlife & Wetlands

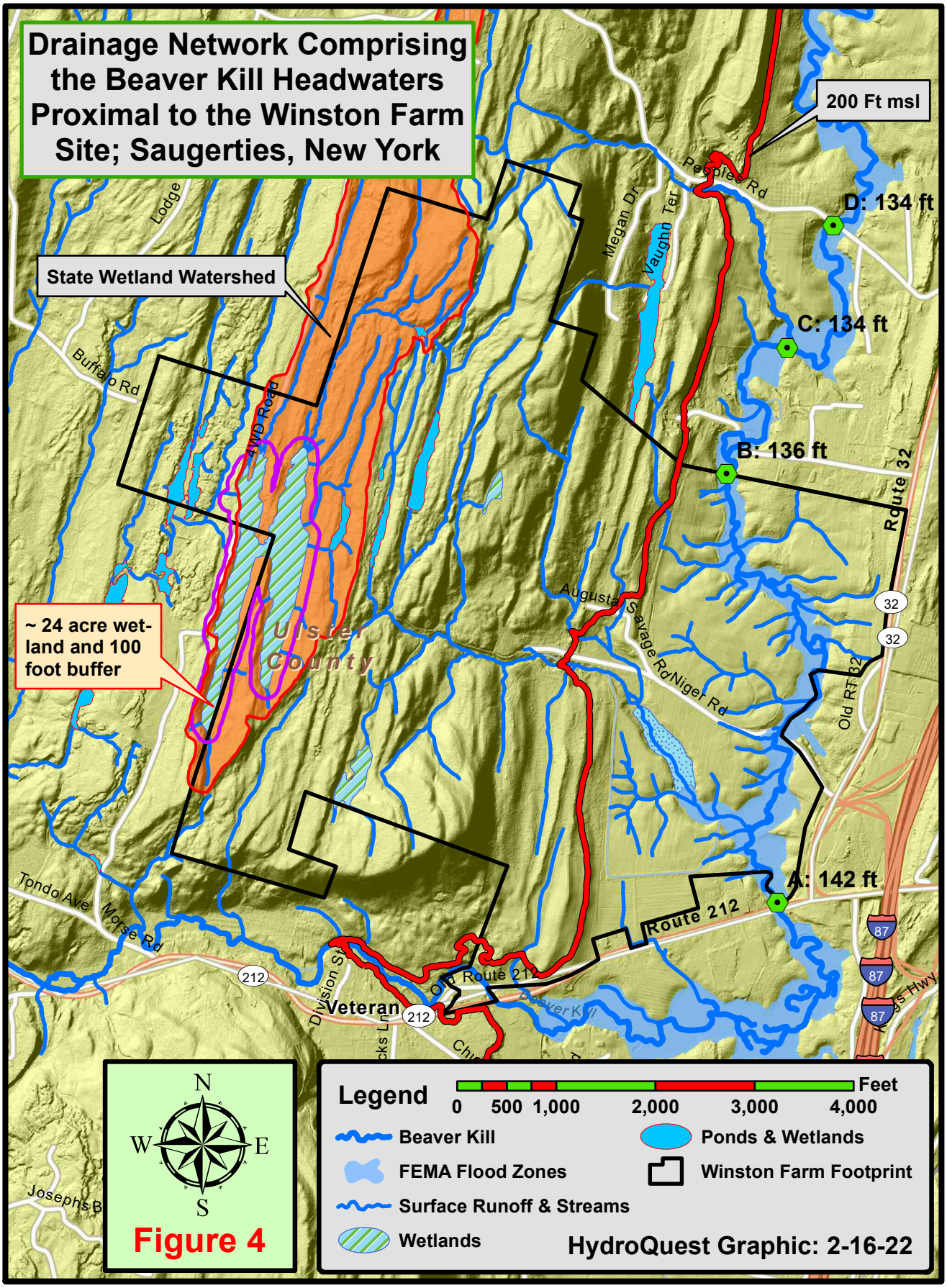
The proposed actions may affect one or more wetlands or other surface water bodies (e.g., streams, rivers, ponds or lakes (Winston Farm FEAF, Part 2, Item 3; Impacts on Surface Water). The Beaver Kill is the main stem stream that traverses through and close to the proposed Winston Farm project site (Figure 2). Several excellent photographs of the Beaver Kill and nearby Winston Farm fields appear in a 2021 article by Brian Hubert (https://hudsonvalleyone.com/2021/12/17/full-seqra-at-winston-farm/). They show the beauty and setting of the Beaver Kill and farm fields and are worth viewing. Delineation and characterization of the surface stream network on and surrounding the Winston Farm site is instrumental in understanding the nature of recharge to the Beaver Kill Aquifer that is deeply buried beneath glacial lake clays and silts that floor the Beaver Kill Valley, as well that to the Beaver Kill.

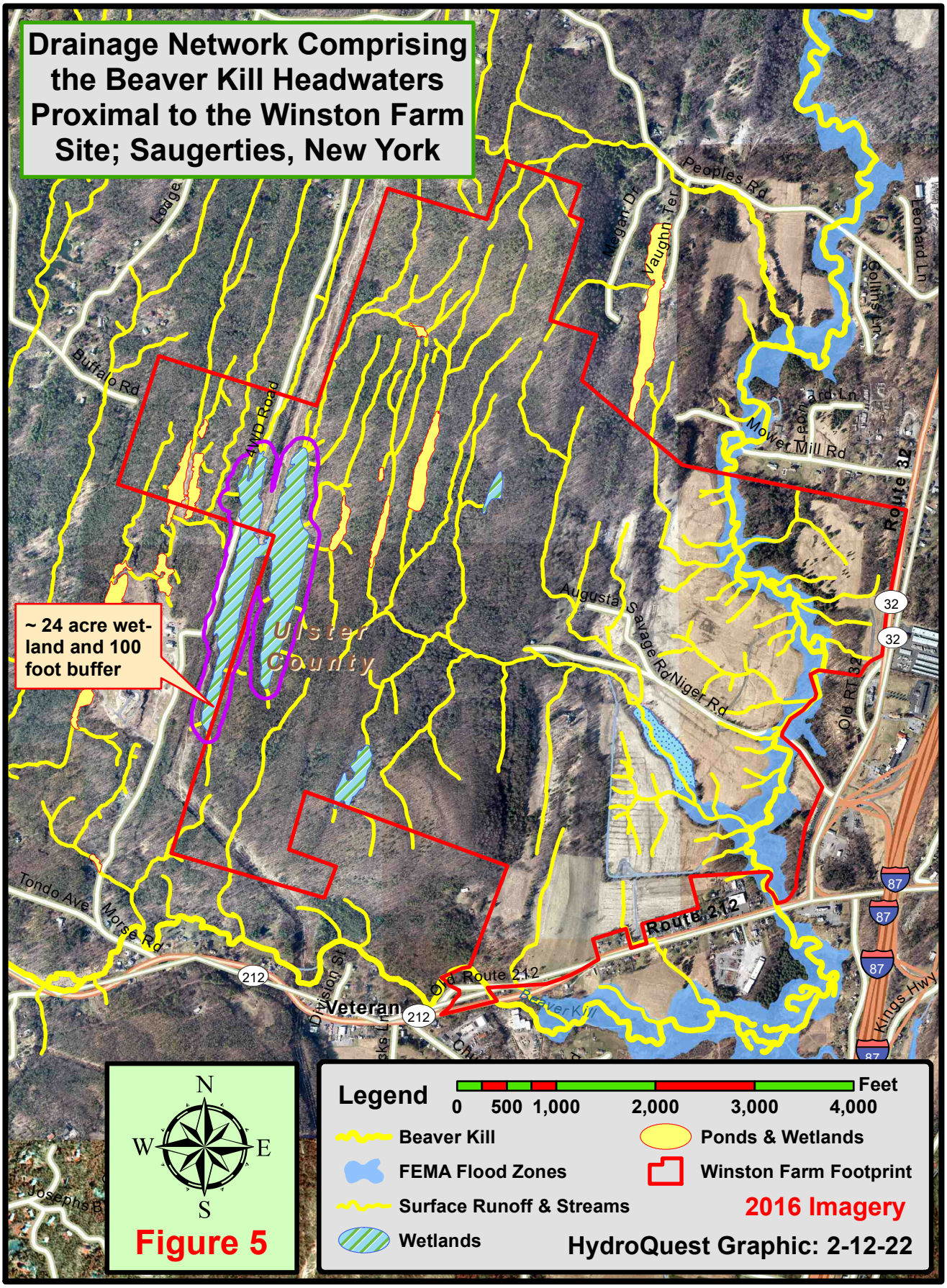
Figure 2. Beaver Kill viewed from Augusta Savage Road in winter.

Figures 3, 4, and 5 depict the surface drainage pattern present both on and beyond the Winston Farm site. Figures 3 and 4 are plotted on base elevational maps processed from a 2014 LiDAR dataset and 2015 topographic one-meter digital elevation model. Figure 5 shows the same features portrayed on a 2016 photo base. From the digital elevation model data, the Ulster County GIS Information Services developed a data set that contains two-foot topographic contour lines for all of Ulster County. The high quality of this data set, combined with analysis of high resolution orthoimagery, allowed highly detailed delineation of surface runoff and stream patterns, as well delineation of the watershed tributary to the NYS wetland portrayed on Figure 3.

Examination of the drainage patterns shown on these figures reveals two distinctly different patterns. The thick red line depicted on Figure 4 traces the 200-foot mean sea level (msl) elevation that traverses through and beyond the Winston Farm project site. This line approximates the break


Drainage Network Comprising the Beaver Kill Headwaters Proximal to the Winston Farm Site; Saugerties, New York
State Wetland Watershed
Paleo-flow route?
NYS Wetland (~24 acres)
Ulster County
Centerville
Veteran
Katsbaan
Route 212
Route 32
Deerhaven Ln
Rivka Rd
Van Vlierden Rd
Van Buskirk Rd
Blue Mountain Rd
Brink Rd
Owls Nest Rd
Hommelville Rd
Harry Wells Rd
W Saugerties Rd
Houtman Rd
Bruin Dr
Fox Den Rd
Doe Rd
Buffalo Rd
Eddy St
Lodge Rd
Northwood Rd
Laurel Ln
Peoples Rd
Megan Dr
Vaughn Ter
Leonard Ln
Collins Ln
Mower Mill Rd
MD Road
Niger Rd
Old Rt 32
Olsen Rd
Solway Rd
Browns Ln
Marys Ave
Tondo Ave
Old Route 212
Division St
Churchland Rd
Churchland Ln
Ploss Rd
Fishcreek Rd
Josephs Blvd
Pine Grove Rd
Pond Ln
George Sickle Rd
Railroad Ave
36
32
212
87
N
S
E
W
Figure 3
Legend
Miles
0 0.15 0.3 0.6 0.9 1.2
Beaver Kill
FEMA Flood Zones
Surface Runoff & Streams
Wetlands
Ponds & Wetlands
Winston Farm Footprint
Plattekill Creek
HydroQuest Graphic: 2-17-22


Drainage Network Comprising the Beaver Kill Headwaters Proximal to the Winston Farm Site; Saugerties, New York
200 Ft msl
D: 134 ft
C: 134 ft
B: 136 ft
A: 142 ft
State Wetland Watershed
~ 24 acre wet-land and 100 foot buffer
Ulster County
Peoples Rd
Megan Dr
Vaughn Ter
Lodge
Buffalo Rd
4WD Road
Augusta
Savage Rd
Niger Rd
Old RT 32
Route 32
Route 212
Old Route 212
Veteran
Division St
Tondo Ave
Morse Rd
Beaver Kill
212
87
Legend
Feet
0 500 1,000 2,000 3,000 4,000
Beaver Kill
Ponds & Wetlands
FEMA Flood Zones
Winston Farm Footprint
Surface Runoff & Streams
Wetlands
HydroQuest Graphic: 2-16-22
N
W
E
S
Figure 4


Drainage Network Comprising the Beaver Kill Headwaters Proximal to the Winston Farm Site; Saugerties, New York
~ 24 acre wet-land and 100 foot buffer
Ulster County
Buffalo Rd
4WD Road
Lodge
Megan Dr
Vaughn Ter
Peoples Rd
Leonard Ln
Collins Ln
Mower Mill Rd
Route 32
Augusta Savage Rd
Niger Rd
Old RT 32
Tondo Ave
Morse Rd
212
Division St
Veteran
Old Route 212
Route 212
Beaver Kill
87
Kings Hwy
N
W
E
S
Figure 5
Legend
0 500 1,000 2,000 3,000 4,000 Feet
Beaver Kill
Ponds & Wetlands
FEMA Flood Zones
Winston Farm Footprint
Surface Runoff & Streams
2016 Imagery
Wetlands
HydroQuest Graphic: 2-12-22

between near surface bedrock-floored upland areas to the west and thick glacial lake clays and silts to the east that have filled a deeply incised gorge that once carried an active stream.

The drainage pattern west of this 200-foot elevational line is of a rectangular pattern that reflects linear joint patterns in the bedrock. Note elongate, linear, stream and wetland orientations trending north-northeast to south-southwest with shorter connecter segments at about 90 degrees to this orientation. These orientations directly correlate with vertical bedrock fractures called joints that are present throughout the region.

Fractures in the bedrock are important because they serve as preferential pathways for surface water and snowmelt to infiltrate downward into the underlying groundwater flow system. This flow provides the primary source water that recharges or replenishes the buried valley or strip aquifer present beneath the Beaver Kill Valley. Major roadway and building construction, utility infrastructure development, and grading at one or more sites may significantly disrupt this naturally-occurring groundwater recharge.

The HydroQuest companion report (January 2022) and this report provide additional characterization of the Beaver Kill Aquifer. Geologic characterization of fracturing in the area reveals the presence of two distinct joint sets (Figure 6). The orientation of numerous vertical fractures (i.e., joints) was measured with a compass and plotted in Rose diagram format. Geologists use Rose diagrams to graphically portray dominant fracture (bedrock joint) orientations within 360-degree compass-like figures. Geologically, major vertical or near-vertical joint orientations in an area normally occur in two distinct directions roughly 90° apart from each other. On the Rose diagram to the right, the longer spokes represent greater fracture frequency and prominence. Note that the prominent joint orientation is approximately N22°E, but commonly ranges between N10°E and N35°E. Similarly, the secondary east-west joint alignment illustrated on the Rose diagram correlates with favorable (expected) stream and surface runoff flow directions.

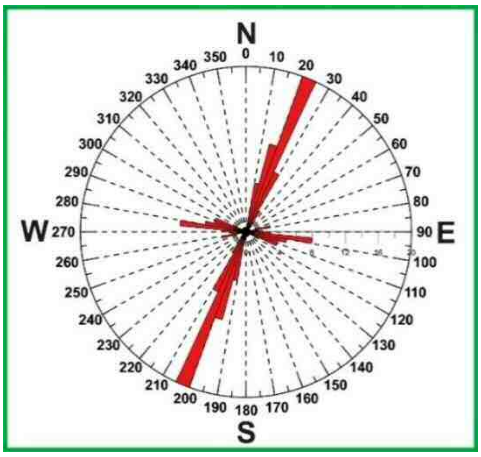


Figure 6. Rose diagram of preferential joint orientations in the Winston Farm area.

Geologic mapping by HydroQuest in the nearby area documents that the most recent glacial advance occurred almost exactly along the same orientation as the prominent joint set (i.e., N22°E to S22°W ± 5°). This coincidence almost certainly increased plucking or removal of bedrock along bedrock exposures now serving as prominent topographic lows where streams and runoff flow.

Reference to Figure 3 shows that the main stem of the Beaver Kill wraps around the Winston Farm project site in an open horseshoe fashion, essentially capturing almost all of the surface runoff and shunting it either to the Beaver Kill or, in part, infiltrating downward along fracture pathways to recharge the buried Beaver Kill Aquifer. Two important points need to be accented here. First, the Plattekill Creek (depicted in purple), and joints proximal to it, almost certainly capture most of

the surface water infiltration from the west and north and discharge it as base flow to the nearest topographic low (i.e., zone of low hydraulic head) which is the channel of the Plattekill Creek. Thus, the most significant headwater source area of both surface water and groundwater recharge to the Beaver Kill Aquifer occurs within this horseshoe-shaped drainage area. Major project development within this area may compromise naturally-functioning recharge to the Beaver Kill Aquifer.

The second important point regarding recharge to the buried Beaver Kill Aquifer is that joint or fracture widths (i.e., apertures) are typically wider and more open to surface water infiltration along the steep flanks of deep gorges and valleys. Figure 7 presents a geologic cross-section schematically showing a 4000-foot west-to-east cross-section across the Beaver Kill Valley. The location of this A-to-B cross-section is shown on Figure 8. It is discussed later in this report. Note that the pre-glacial valley bottom was over 200 feet in depth before it was filled with sediments deposited into former Glacial Lake Albany. Thus, there is a direct correlation between the rectangular joint-controlled stream network present in the upland area portion of the Winston Farm site and the recharge it provides to the Beaver Kill Aquifer.

HydroQuest hydrologic mapping of the lowland portion of the Winston Farm site, situated east of the 200-foot elevation contour depicted on Figure 4, reveals a dendritic drainage pattern. This branched, tree-like, pattern is found on soft substrates or homogeneous rocks where bedrock fracture control is not present. Here, as seen on the Figure 9 image below, the Beaver Kill is a meandering, sometimes braided (multiple channel), stream type slightly entrenched into underlying soft lacustrine or lake clays and silts. Figure 4 shows this typical Beaver Kill pattern and the stream's wide, well-developed, floodplain.

Hydraulic Gradient of the Beaver Kill				
Map Location	***Elevation (ft msl)***	***~ Reach Length (ft)***	***Hydraulic Gradient***	***Ft/Mile***
A	142	0	------	------
B	136	6185	0.00097	5.1
C	134	2533	0.00079	4.2
D	134	2434	0	0
E	120	14186	0.00099	5.2
F	118	2398	0.00083	4.7
G	116	2245	0.00089	3.7
H	114	2888	0.00069	3.7
I	112	1952	0.00102	5.4
J	110	1360	0.00147	7.8
K	106	460	0.0087	45.9
L	104	1455	0.00137	7.3
M	100	2215	0.00181	9.5
A to M	**142 to 100**	**40311**	**0.00104**	**5.5**

Table 1. Hydraulic gradients along the Beaver Kill.

Schematic: Recharge Pathways to the Beaver Kill Aquifer

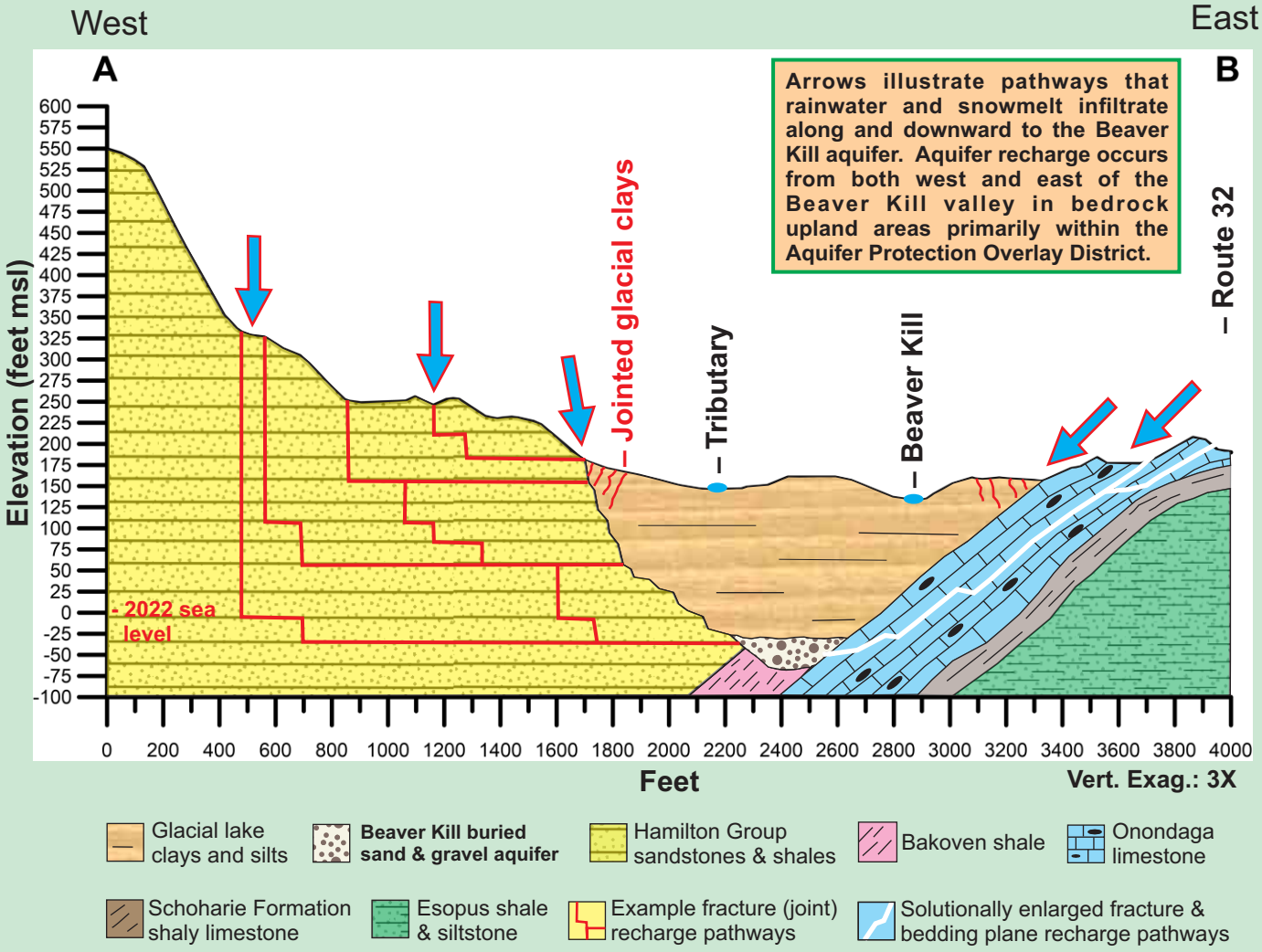
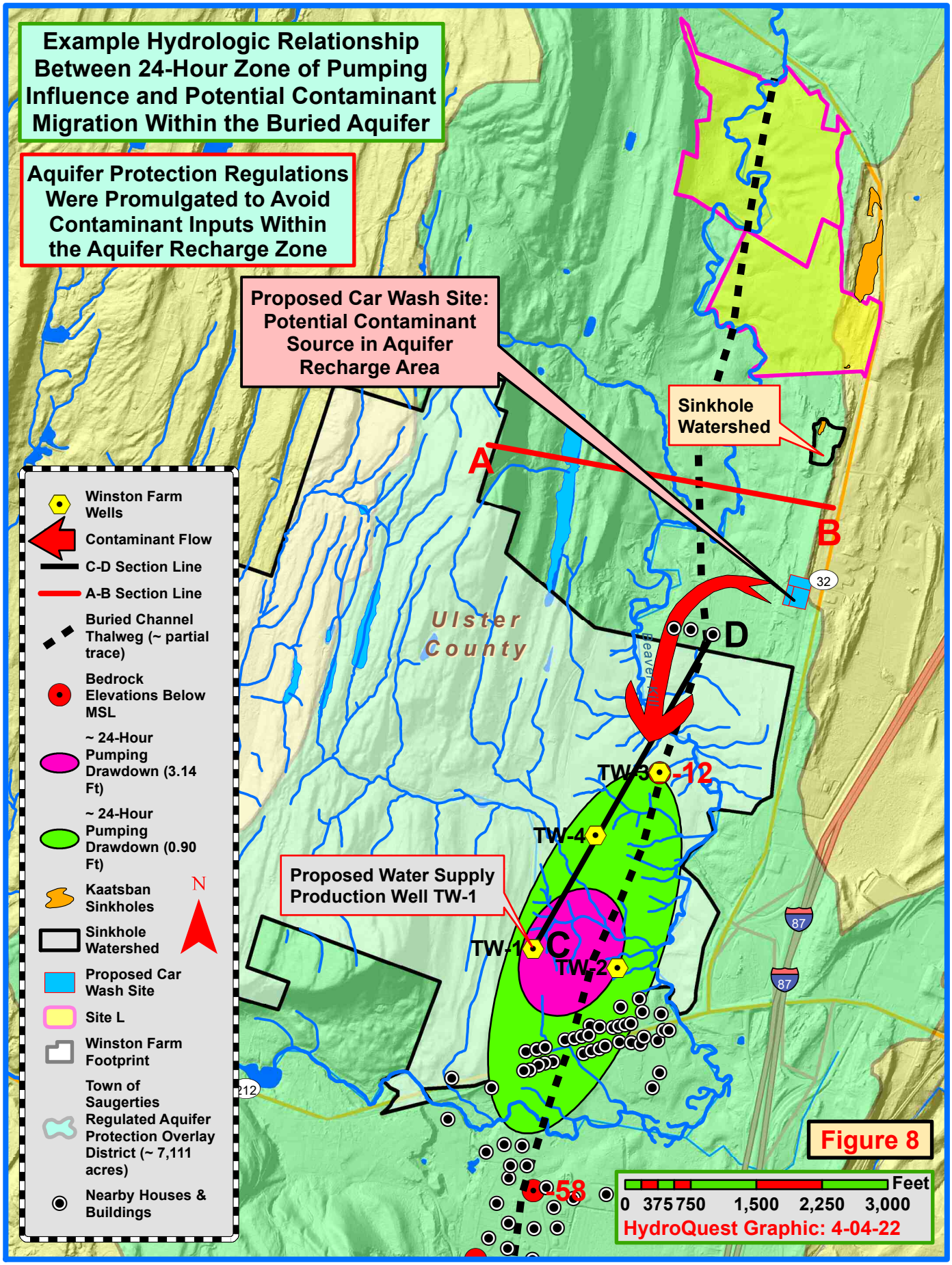


Figure 7

HydroQuest Graphic: April 2022


Example Hydrologic Relationship Between 24-Hour Zone of Pumping Influence and Potential Contaminant Migration Within the Buried Aquifer
Aquifer Protection Regulations Were Promulgated to Avoid Contaminant Inputs Within the Aquifer Recharge Zone
Proposed Car Wash Site: Potential Contaminant Source in Aquifer Recharge Area
Sinkhole Watershed
A
B
C
D
Ulster County
TW-1
TW-2
TW-3
TW-4
-12
-58
Proposed Water Supply Production Well TW-1
Winston Farm Wells
Contaminant Flow
C-D Section Line
A-B Section Line
Buried Channel Thalweg (~ partial trace)
Bedrock Elevations Below MSL
~ 24-Hour Pumping Drawdown (3.14 Ft)
~ 24-Hour Pumping Drawdown (0.90 Ft)
Kaatsban Sinkholes
Sinkhole Watershed
Proposed Car Wash Site
Site L
Winston Farm Footprint
Town of Saugerties Regulated Aquifer Protection Overlay District (~ 7,111 acres)
Nearby Houses & Buildings
N
Feet
0 375 750 1,500 2,250 3,000
HydroQuest Graphic: 4-04-22
Figure 8

Meandering or sinuous streams form on low gradient landforms. It is important to characterize these gradients because low gradient streams, especially in headwater reaches like that in the Winston Farm area, have limited ability to assimilate contaminant additions (e.g., wastewater treatment plant effluent that contains organic materials that are decomposed by microorganisms, which use oxygen in the process). This stems from a number of factors including low stream gradients and seasonally low discharge, low flow velocities and water depths, limited stream reaeration and oxygenation, reduced biochemical oxygen demand (BOD) concentrations, and increased pollutant loading. Together, these factors can lead to water quality degradation, fish kills, reduced aquatic species health and diversity, and adverse impact to ecosystems and wildlife. Table 1 documents the hydraulic gradient or slope of the Beaver Kill between a number of locations that are labeled A through M on Figure 1. These locations extend from the southern boundary of the Winston Farm site (Location A, Figure 4), to the northern boundary of the Winston Farm site (Location B, Figure 4), and northward until the Beaver Kill joins the Kaaterskill Creek in Asbury (Location M, Figure 1). The hydraulic gradient of the Beaver Kill from the Winston Farm's southern border to Kaaterskill Creek is 0.001 which equates to an elevational decrease of 5.5 feet per mile. This very low stream gradient provides little oxygenation potential, as occurs in higher gradient streams with turbulent flow and small or large water cascades. The braided, meandering nature of the Beaver Kill is illustrated on Figures 4 and 9.

Figure 9. Braided, meandering, form of the Beaver Kill.

The proposed Winston Farm project would discharge wastewater treatment effluent to the Beaver Kill which may adversely impact plant and animal species. Winston Farm FEAF, Part 2, section 7 (Impact on Plants and Animals) is designed to assess if a proposed action may result in a loss of flora or fauna. Project construction would pose a moderate to large impact. A number of items listed under this heading may be impacted. Some include:

> "*b. The proposed action may result in a reduction or degradation of any habitat used by any rare, threatened or endangered species, as listed by New York State or the Federal government.*
> *c. The proposed action may cause reduction in population, or loss of individuals, of any species of special concern or conservation need, as listed by New York State or the Federal government, that use the site, or are found on, over, or near the site.*
> *d. The proposed action may result in a reduction or degradation of any habitat used by any species of special concern and conservation need, as listed by New York State or the Federal government*."

Barbour (1991), a Hudsonia field biologist, characterized the Beaver Kill as having "… *floodplain forests of the Beaver Kill, a deep, slow, clay-bottomed, biologically rich stream*." His findings within the wooded Beaver Kill floodplain habitat included the wood turtle (*Clemmys insculpta*), a species of special concern. Barbour states:

> "*The wood turtle requires a combination of fields, wet meadows, and woods edges for foraging, and unpolluted pond or sluggish stream habitats with undercut banks or muskrat burrows for hibernating. High mortality is common. The species will become rarer in our region as its habitats are altered through the loss of agricultural lands and other changes, and as motor vehicle traffic increases*."

Significantly, Barbour identified the Beaver Kill floodplain as a habitat supporting winged monkeyflower (*Mimulus alatus*), a rare New York State native plant. This is a protected plant pursuant to Section 9-1503 of the Environmental Conservation Law. Barbour notes this is one of the largest winged monkeyflower populations in the state. If more recent biological studies have not already been conducted, they are warranted.

The proposed Winston Farm Site Masterplan includes construction of a 4-acre waste package plant immediately west of the Beaver Kill. The Winston Farm's NYSDEC Full Environmental Assessment Form (FEAF) Part 2, Section 3 (Impacts on Surface Water), provides the lead agency with the identification of resources that could be affected by a proposed project, including Items g, i, and k:

> "*g. The proposed action may include construction of one or more outfall(s) for discharge of wastewater to surface water(s).*
> *i. The proposed action may affect the water quality of any water bodies within or downstream of the site of the proposed action.*
> *k. The proposed action may require the construction of new, or expansion of existing, wastewater treatment facilities."*

Contaminant additions to the Beaver Kill may degrade its water quality and species habitat. Furthermore, grading, construction, road work, and utility line installations in farm fields adjacent to the Beaver Kill would disrupt the existing surficial drainage pattern and nutrient fluxes that presently make the Beaver Kill and its floodplain an excellent wildlife habitat and Class C stream with a classified best use as fishing (Regulation 863-111).

Importantly, reference to Figures 3, 4, and 5 show that the Winston Farm drainage network and watershed area tributary to the proposed wastewater treatment plant is situated in the relatively small headwater region of the Beaver Kill. Thus, during dry times, both stream flow and the assimilative capacity of the stream are low, especially in the low gradient stream, thereby limiting its ability to absorb wastewater effluent.

Reference to the Winston Farm FEAF, Part 2, section 11 (Impact on Open Space and Recreation) helps lead agencies inventory proposed actions that may result in a loss of recreational opportunities or a reduction of an open space resource as designated in any adopted municipal open space plan. Item 11.a. directly applies to the Winston Farm development project:

> "*a. The proposed action may result in an impairment of natural functions, or "ecosystem services", provided by an undeveloped area, including but not limited to stormwater storage, nutrient cycling, wildlife habitat*."

The Town of Saugerties' 2021 Comprehensive Plan update Goal #8 (Natural Resources Protection) seeks to promote awareness and protection of natural resources, wilderness, and scenic areas. For example, Items 8.2 and 8.3 state:

> "*8.2 Make efforts to identify and protect our scenic resources, including open space, wildlife habitats, rare or endangered plant communities, plus mountain and river views and vistas.*
> *8.3 Promote a land use pattern that protects air quality plus surface and groundwater resources, while working to eliminate (or minimize) all sources of pollution, but not limited to road salt and leaching dump sites*."

The Town of Saugerties has existing Aquifer Protection Overlay District regulations designed to protect the aquifer (Code of Ordinances; Part II. General Legislation; Chapter 245. Zoning; Article VI. General Regulations, § 245-25. Aquifer Protection Overlay District). The regulations for this overlay district prohibit a number of uses that could contaminate the aquifer. For example, Section C, Item (1)(r) prohibited uses lists: *Municipal or industrial sewage treatment facilities with disposal of primary or secondary effluent*.

The Winston Farm Site Master Plan, dated September 2021 depicts a 4-acre "*Waste Package Plant"* close to the Beaver Kill for stormwater management. Similarly, page 6 of the Winston Farm Full EAF, Part 1, Section D.2. (Project Operations), Subsection d.iv., revised 9-22-21, asks "*Will a new wastewater (sewage) treatment district be formed to serve the project site?*" and has a Yes answer. The FEAF states that Applicant Saugerties Farms LLC will form a new district to serve the project site with the Beaver Kill to be used as the receiving water for the wastewater discharge from a "*New on-site Package Wastewater Treatment Plant*".

At this time, the Town of Saugerties Planning Board has to consider two potential zoning amendments (Denier car wash and Winston Farm). If approved, both zoning amendments could potentially compromise the integrity of the aquifer the overlay district was established to protect.

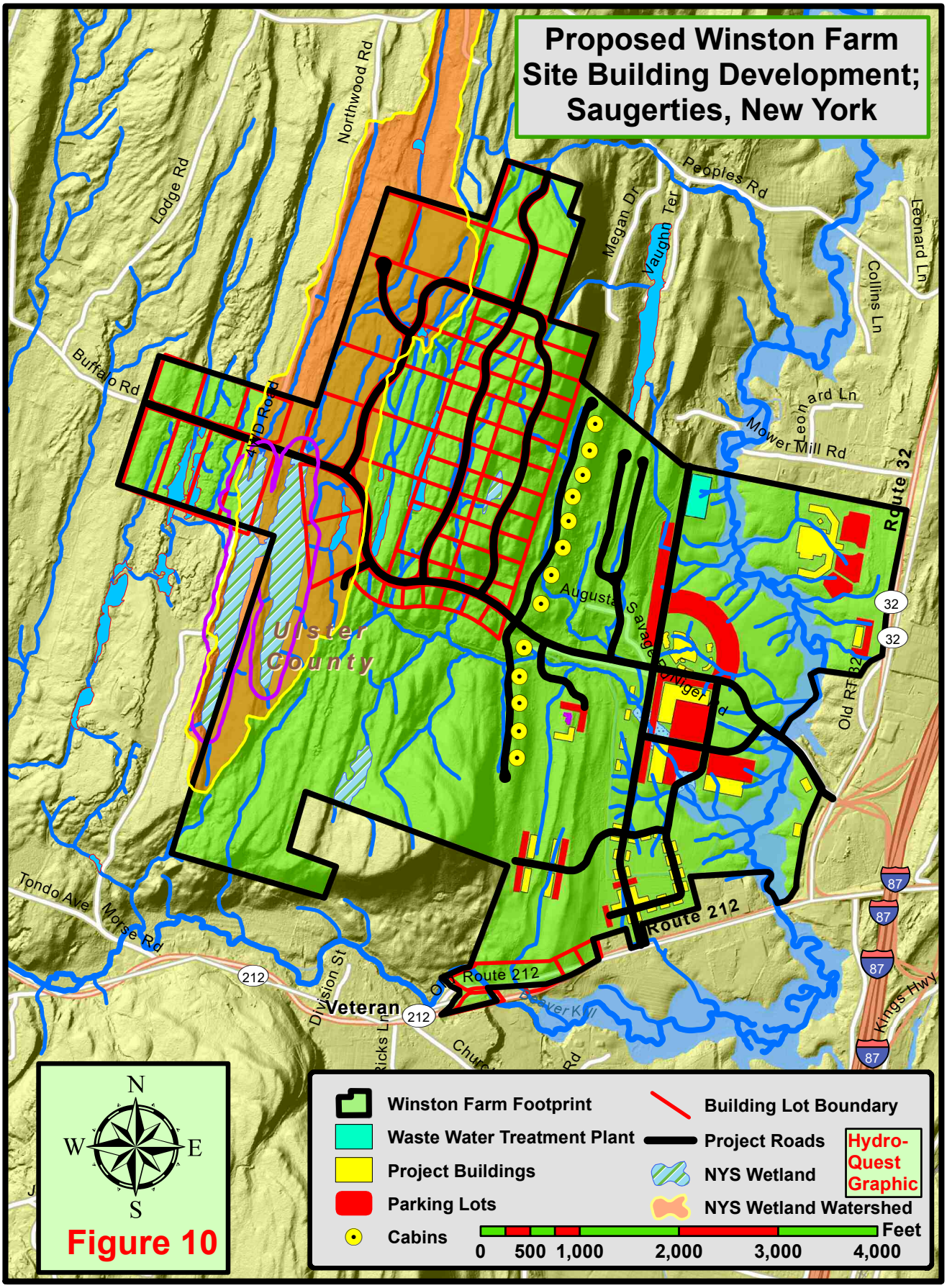
Wetlands

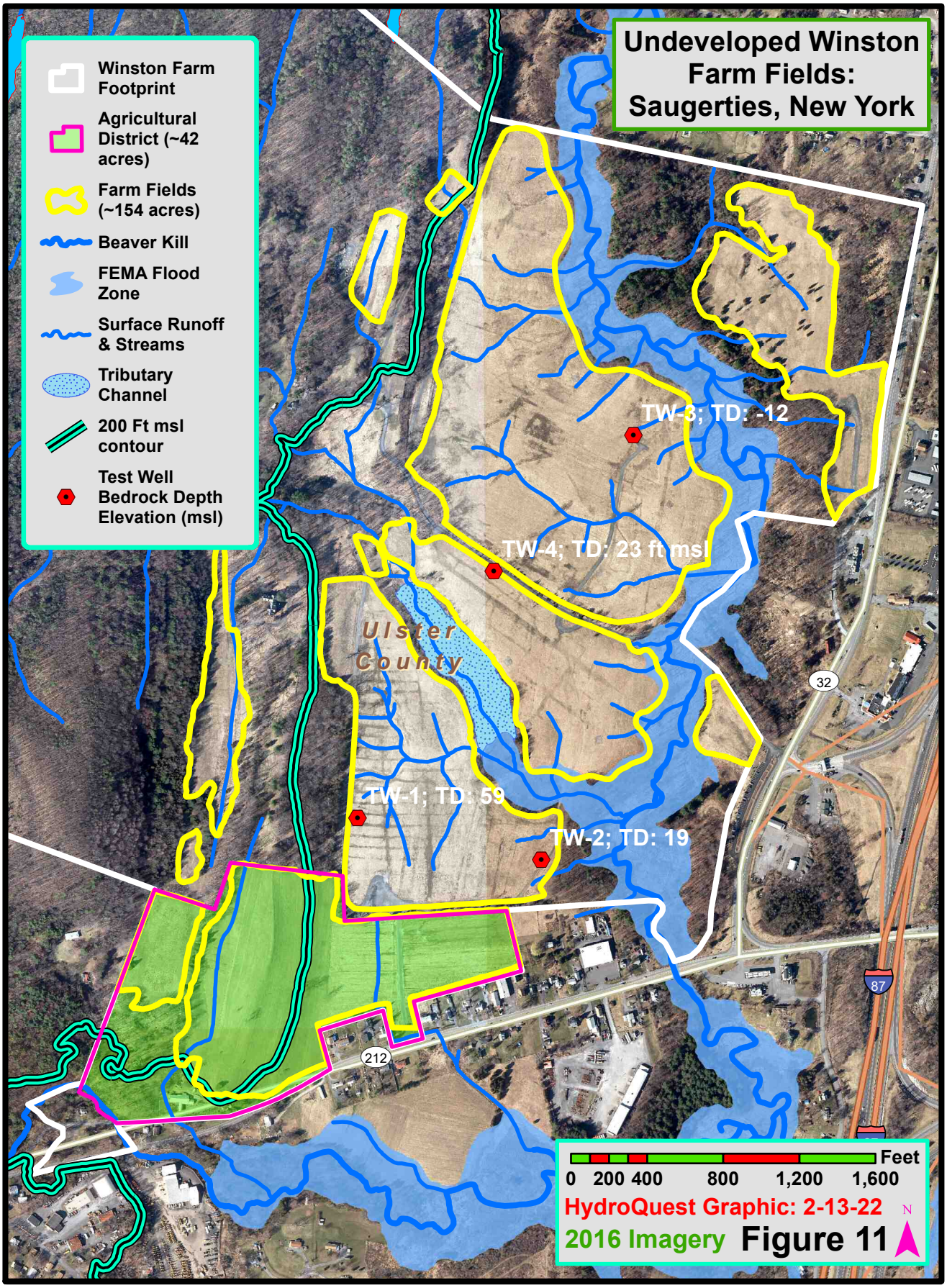
Wetlands and streams serve as natural habitat for many species of plants and animals. Species diversity and the health of wetlands and streams rely upon a combination of overland and base flow to provide an ongoing supply of water and nutrients. For this reason, wetlands and the Beaver Kill must not be considered in isolation as singular wetlands or stream channels. Their continued health and viability require input from large upslope areas that drain to them. Also, wetlands are very important in recharging groundwater supplies.

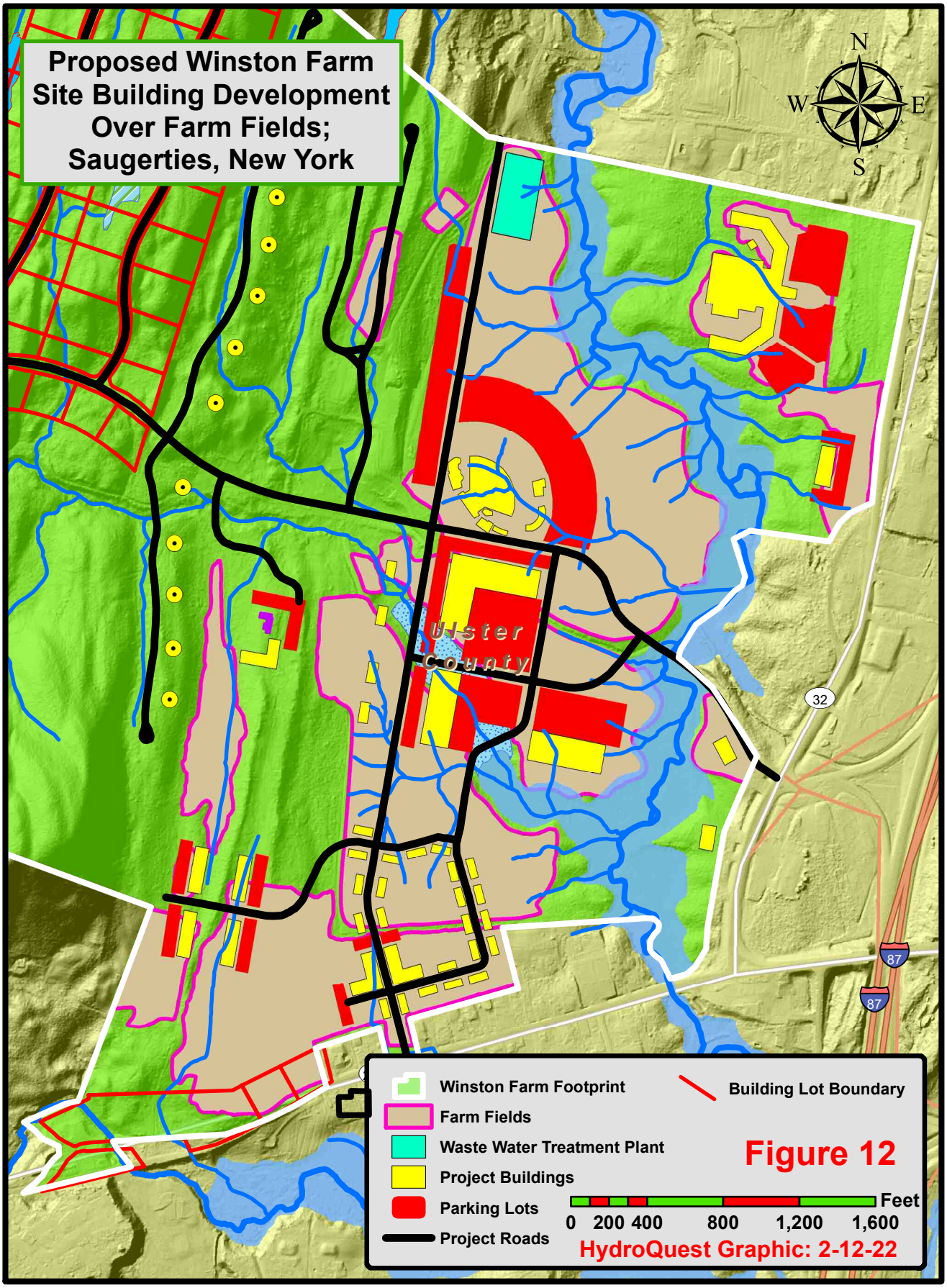
Wetlands are critical for bird health and population stability, and numerous freshwater wetlands are found throughout the state. Approximately one-third of North American bird species use wetlands for food, shelter, or breeding, and one hundred thirty-eight species and subspecies of birds in the U.S. are designated as wetland-dependent, including many threatened or endangered birds in New York State like the Black Rail, Pied-billed Grebe, and Short-eared Owl. Protecting these birds' habitats is essential to their future survival.

The 1975 Freshwater Wetlands Act was passed with the intent to preserve and protect NYS wetlands greater than 12.4 acres in size. An adjacent area of 100 feet outward from wetland edges is protected by regulation. While this buffer distance is designed to provide protection for State wetlands, it fails to fully account for essential water and nutrient inputs. The U.S. Army Corps of Engineers also protects wetlands, irrespective of size, under Section 404 of the Clean Water Act.

A number of wetlands are present on and extending beyond the Winston Farm site (Figures 3, 4, and 5). Based on mapping using high resolution orthoimagery and elevational data, the largest of these wetlands is approximately 24-acres in size (Figure 4). Its watershed was mapped through detailed analysis of two-foot elevational data and is portrayed on Figure 3. Wetland delineation via field mapping can be used to refine the wetland border. Figure 10 depicts many of the proposed site development features digitized from Passero Associates' September 2021 Winston Farm Site Masterplan. Reference to this figure shows that some building lots would extend up to this NYS wetland. Also, numerous proposed building lots and roadways would compromise naturally existing surface flow, nutrient additions, and shallow groundwater flow to this wetland that presently make it healthy. Advancement of any development within the watershed tributary to this NYS wetland should be preceded by detailed wetland, biologic, and hydrologic assessment.


Proposed Winston Farm Site Building Development; Saugerties, New York
Northwood Rd
Lodge Rd
Buffalo Rd
Peoples Rd
Megan Dr
Vaughn Ter
Leonard Ln
Collins Ln
Mower Mill Rd
Route 32
Ulster County
Old Rte 32
Route 212
Veteran
Division St
Tondo Ave
Morse Rd
Kings Hwy
N
W
E
S
Figure 10
Winston Farm Footprint
Waste Water Treatment Plant
Project Buildings
Parking Lots
Cabins
Building Lot Boundary
Project Roads
NYS Wetland
NYS Wetland Watershed
Hydro-Quest Graphic
Feet
0 500 1,000 2,000 3,000 4,000


Undeveloped Winston Farm Fields: Saugerties, New York
Winston Farm Footprint
Agricultural District (~42 acres)
Farm Fields (~154 acres)
Beaver Kill
FEMA Flood Zone
Surface Runoff & Streams
Tributary Channel
200 Ft msl contour
Test Well Bedrock Depth Elevation (msl)
TW-3; TD: -12
TW-4; TD: 23 ft msl
TW-1; TD: 59
TW-2; TD: 19
Ulster County
32
212
87
Feet
0 200 400 800 1,200 1,600
HydroQuest Graphic: 2-13-22
2016 Imagery
Figure 11
N


Proposed Winston Farm Site Building Development Over Farm Fields; Saugerties, New York
N
W
E
S
Ulster County
32
87
87
Winston Farm Footprint
Farm Fields
Waste Water Treatment Plant
Project Buildings
Parking Lots
Project Roads
Building Lot Boundary
Figure 12
Feet
0 200 400 800 1,200 1,600
HydroQuest Graphic: 2-12-22

Farmland and Agricultural Districts

Farmlands are valuable resources that span from agriculture to wildlife habitat and aesthetic character (Figures 11, 12, 13, and 14). Developmental pressure over time has significantly reduced the number of farmlands remaining on the landscape. Multiple years of high resolution orthoimagery were used to map Winston Farm farmlands. Figure 11 depicts twelve undeveloped farmed areas ranging in size from less than one-acre to 51-acres. Together, they encompass about 154-acres. The two southernmost fields that encompass about 42-acres are mapped as being part of Agricultural District fields and appear in Cornell University Geospatial Information Repository's and NYS Department of Agriculture and Markets' 2018 GIS data files. These lands are under the protection of the NYS Agricultural District Law, administered by the Department of Agriculture and Markets. 2003 legislation allows lands to be added to districts on an annual basis. For example, the Ulster County Legislature accepts applications from landowners who want to have their lands included within a state Certified Agricultural District. Agricultural district designation does not put restrictions on what property owners can do to the land. Residential and commercial development is allowed. Districts "*provide benefits that help make and keep farming as a viable economic activity, thereby maintaining land in active agricultural use*." Also, as documented by Barbour, farmlands provide valuable habitat for many plant and animal species.

Figure 13. Winston Farm field.

Figure 14. Winter view of a Winston Farm field.

The NYS SEQRA Full Environmental Assessment Form, Part 2 prompts lead agencies to inventory potential Impact on Agricultural Resources (Section 8). Among the issues raised for consideration are Items 8d, 8f, and 8h:

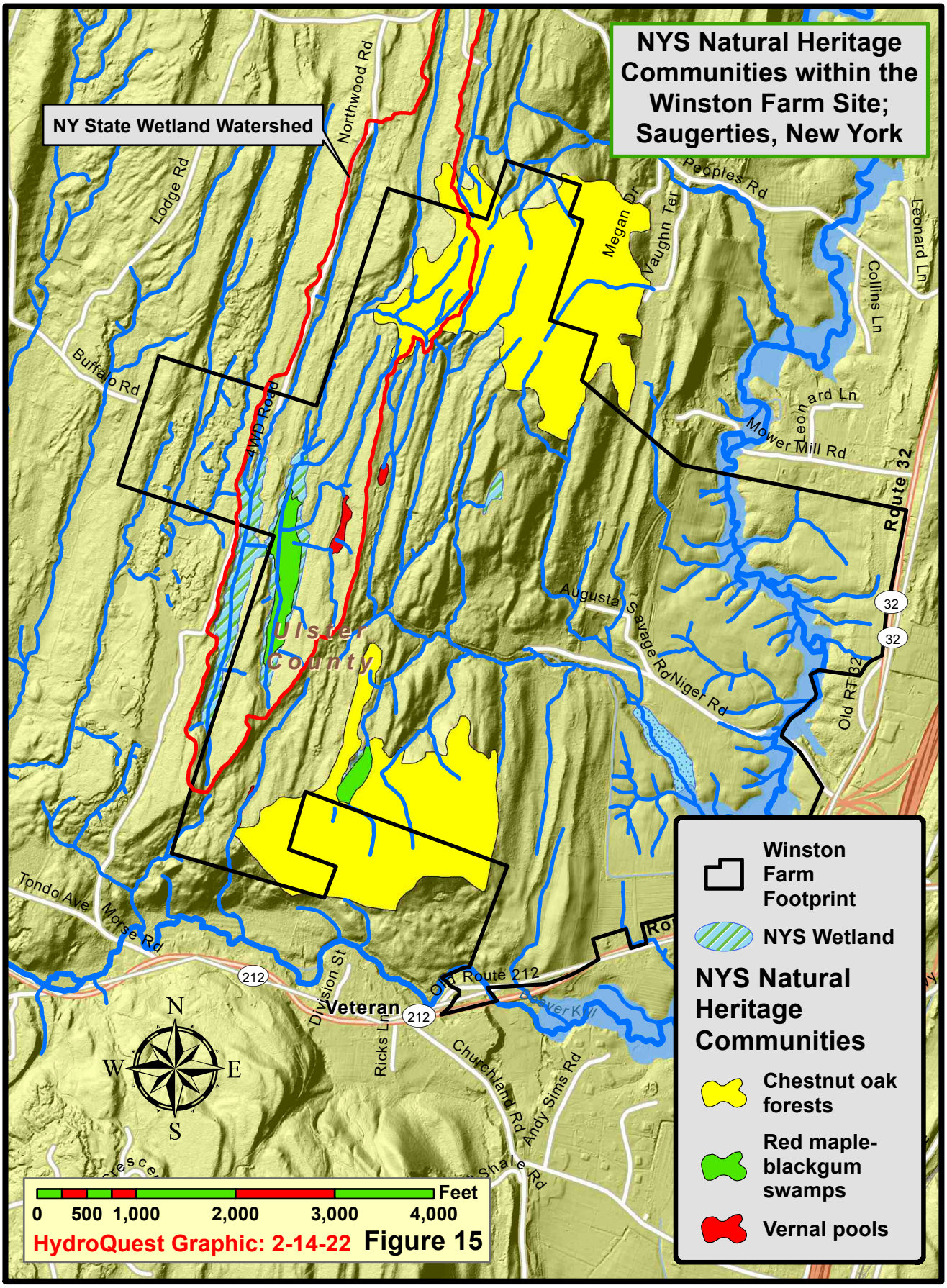
"*d. The proposed action may irreversibly convert agricultural land to non-agricultural uses, either more than 2.5 acres if located in an Agricultural District, or more than 10 acres if not within an Agricultural District*.
f. The proposed action may result, directly or indirectly, in increased development potential or pressure on farmland.
h. Other impacts:" (for Winston Farm) Disruption of existing surficial runoff, flow, and nutrient delivery to the Beaver Kill.

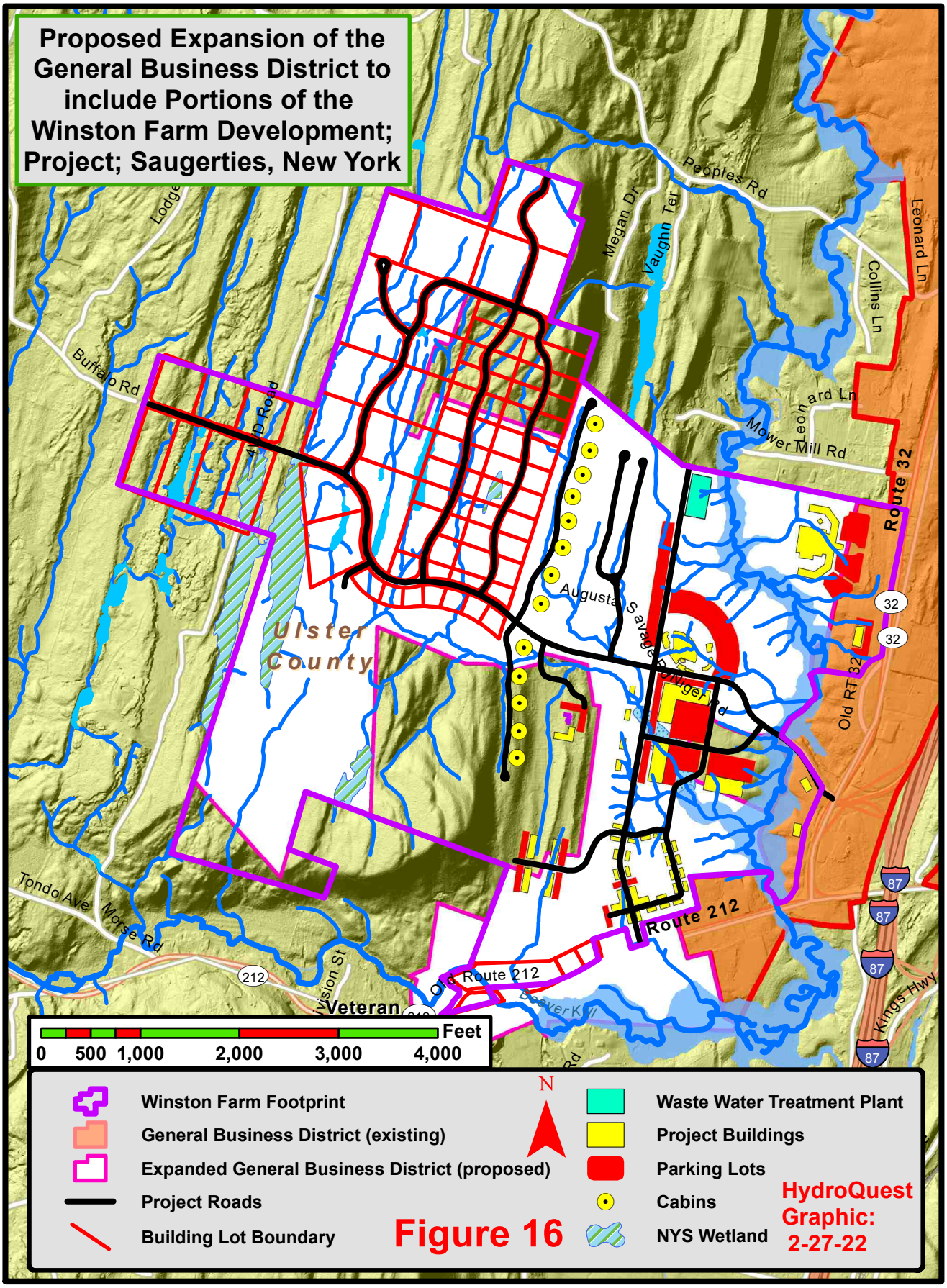
Similarly, the proposed action at Winston Farm may involve construction on, or physical alteration of, the land surface of the proposed site (Winston Farm FEAF, Part 2, Section 1). In regard to Section 1.h. Other Impacts, Winston Farm development may adversely impact recharge to the Beaver Kill Aquifer. Water withdrawal from this aquifer is being considered to supplement existing Saugerties water sources.

The proposed Winston Farm development would irreversibly convert much farmland to non-agricultural use. Figure 12 presents proposed Winston Farm site building development over farm fields digitized into GIS map format from Passero Associates' September 2021 Winston Farm Site Masterplan map. Proposed site development would irreversibly alter working farm fields and would potentially compromise the Beaver Kill ecosystem discussed by Barbour (1991). Barbour points out that an important feature of the habitat quality on Winston Farm is the isolation from heavily traveled roads and from human activity in general.

NYS Natural Heritage Communities

There are a number of documented NYS Natural Heritage Communities within the Winston Farm site that would be impacted by development of the proposed project. Figure 15 shows chestnut oak forests, red maple-blackgum swamps, and vernal pools that should be evaluated as part of the SEQRA process. Comparison with Figure 16 and the Passero Associates' September 2021 Winston Farm Site Masterplan map shows that project development (e.g., numerous estate and single family building lots, roads, utilities, Adventure Park) would adversely impact some of these natural resources (chestnut oak forests), as well as the NYS wetland's red maple-blackgum swamp. Also, as seen on Figure 16, Proposed Expansion of the General Business District [aka Planned Development Overlay District]) would infringe upon much of the Natural Heritage Communities depicted. Furthermore, some of the proposed Winston Farm development project would extend beyond the expanded General Business District boundaries either into or very close to a chestnut oak forest (e.g., cabin development).


NYS Natural Heritage Communities within the Winston Farm Site; Saugerties, New York
NY State Wetland Watershed
Northwood Rd
Lodge Rd
Buffalo Rd
4WD Road
Peoples Rd
Megan Dr
Vaughn Ter
Leonard Ln
Collins Ln
Mower Mill Rd
Route 32
Augusta
Savage Rd
Niger Rd
Old Rte 32
Ulster County
Tondo Ave
Morse Rd
212
Division St
Veteran
Old Route 212
Ricks Ln
Churchland Rd
Andy Sims Rd
Shale Rd
Winston Farm Footprint
NYS Wetland
NYS Natural Heritage Communities
Chestnut oak forests
Red maple-blackgum swamps
Vernal pools
N
W
E
S
0 500 1,000 2,000 3,000 4,000 Feet
HydroQuest Graphic: 2-14-22 Figure 15


Proposed Expansion of the General Business District to include Portions of the Winston Farm Development; Project; Saugerties, New York
Peoples Rd
Megan Dr
Vaughn Ter
Leonard Ln
Collins Ln
Buffalo Rd
4WD Road
Mower Mill Rd
Route 32
Augusta Savage Dr
Old RT 32
Ulster County
Tondo Ave
Morse Rd
212
Veteran
Old Route 212
Route 212
Beaver Kill Rd
Kings Hwy
87
0 500 1,000 2,000 3,000 4,000 Feet
N
Winston Farm Footprint
General Business District (existing)
Expanded General Business District (proposed)
Project Roads
Building Lot Boundary
Waste Water Treatment Plant
Project Buildings
Parking Lots
Cabins
NYS Wetland
Figure 16
HydroQuest Graphic: 2-27-22

Aquifer Protection Overlay District

The Town of Saugerties established the Aquifer Protection Overlay District "*to preserve the quality and quantity of the Town's groundwater resources in order to ensure a safe and adequate water supply for present and future generations and to preserve groundwater resources currently in use and those aquifers having potential for a future use as a public water supply*." HydroQuest digitized the district boundaries and brought them into Geographic Information System (GIS) format (Figure 1). Almost certainly, district formation stems from mid-1990s era consideration being given to constructing a regional mega-dump (aka landfill) at two locations within this district, one being on the Winston Farm site, one at Site L (Figure 8). This is discussed by HydroQuest (January 2022). For reasons detailed in that companion report and within this report these locations are not suitable for a landfill (e.g., vulnerable karst setting, recharge area for the buried Beaver Kill Aquifer, soft clay substrate). In large part, Site L was removed from consideration from potential landfill siting because HydroQuest (working for both Saugerties and the Winston Farm Alliance) documented the presence of a well-karstified carbonate aquifer west of Route 32 proximal to these sites. Additional information regarding the Aquifer Protection Overlay District is provided below.

AP Aquifer Protection Overlay District. The Town of Saugerties Chapter 245 Zoning Law was adopted by the Town Board of the Town of Saugerties 11-13-1989 by L.L. No. 3-1989; amended in its entirety 4-16-2008 by L.L. No. 1-2008. A Town of Saugerties Zoning District Overlays map dated 1-22-10 depicts the Town's Aquifer Protection Overlay Zone in a black dot pattern. This zone is portrayed on HydroQuest Figure 1 in this report as a light green color. Town of Saugerties zoning district regulations (§ 245-6) established the Aquifer Protection Overlay District, "*the purpose of which is to establish regulations for activities over identified aquifers to protect groundwater resources from degradation*." Section § 245-7 states: "*The location and boundaries of the zoning districts established in § 245-6 are shown on the map entitled "Town of Saugerties Zoning Map" (Map 1 of 2 and Map 2 of 2). Said map, together with everything shown thereon and amendments thereto, is hereby adopted by reference and accompanies and is declared to be an appurtenant part of this chapter. Said map indicating the latest amendments shall be kept up-to-date in the office of the Town Clerk for the use and benefit of the general public*."

Long-term water quality protection within the 7000^{+}-acre Town of Saugerties' Aquifer Protection Overlay District would be best accomplished by strongly supporting preservation of all existing regulations. A detailed discussion of the value and paramount importance of protecting water quality present in the aquifer present beneath the Beaver Kill Valley was established by HydroQuest in a January 8, 2022 companion report titled: *Ground Water/Aquifer Protection in the Town of Saugerties* (25 pages), as well as by NYRWA (2005). These reports stress the need to protect this valuable resource for future growth in the Town of Saugerties and the wisdom of not compromising its integrity by amending zoning to allow site-specific, contaminant-rich, land uses prohibited within the Aquifer Protection Overlay District. While many actions submitted to the Town of Saugerties Planning Board raise issues about water quality protection, review of the proposed Winston Farm Planned Development District should also focus on protecting an adequate quantity of water for the Town's future.

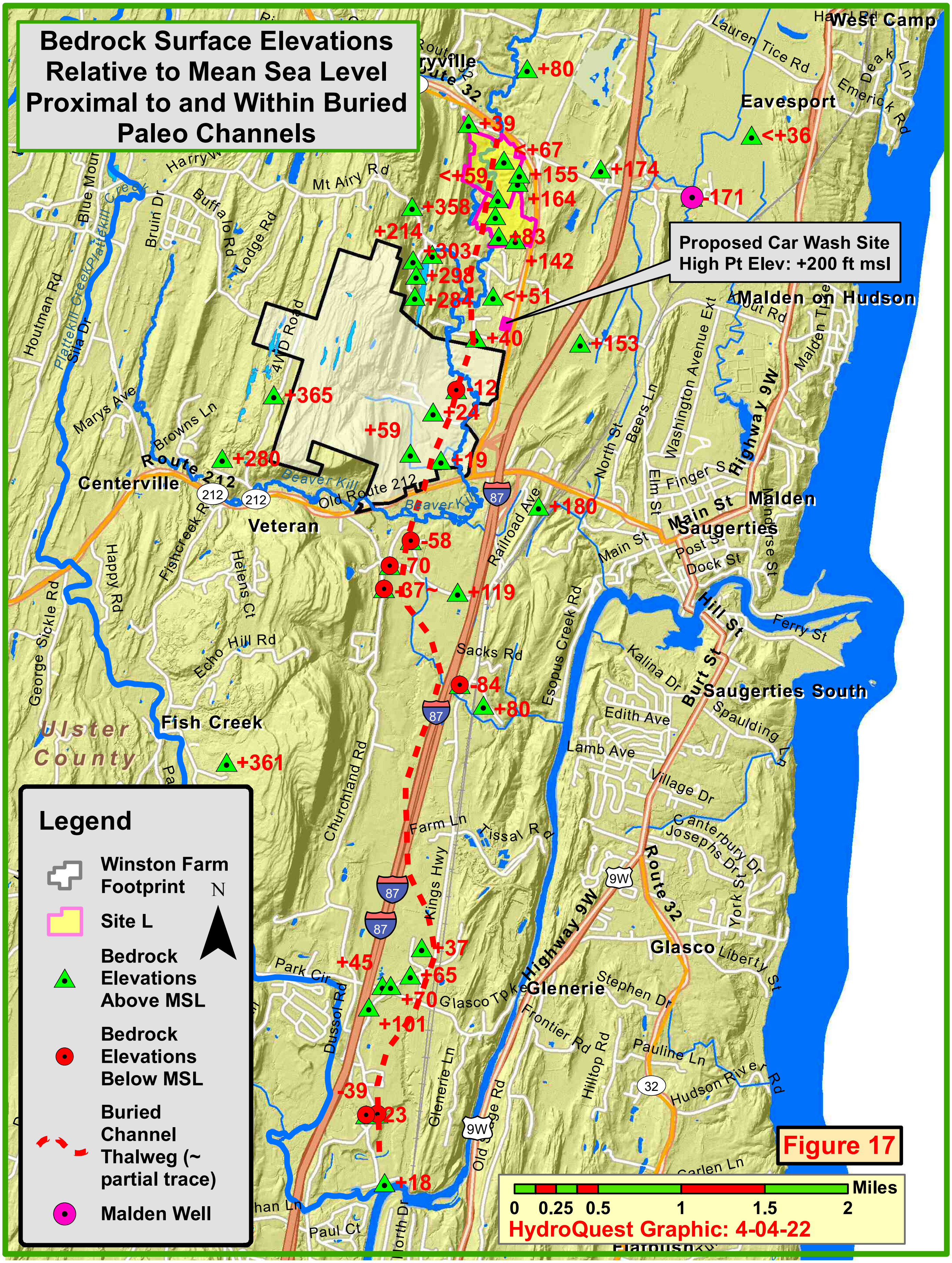
Geomorphic Setting of the Beaver Kill Aquifer

Aquifer and water supply protection and use require a solid understanding of land use above it and its physical character, composition, vertical and lateral extent, safe yield and recharge and discharge locations. A key recommendation made to the Town of Saugerties by HydroQuest (January 2022) was to "*Initiate planning to more fully characterize the Beaver Kill Aquifer and its safe yield*." While this April 2022 companion report (to the January 8, 2022 HydroQuest report) provides much additional aquifer characterization, much more should be learned prior to considering to commit Beaver Kill Aquifer water present beneath the Winston Farm site to a single or even, potentially, multiple large users (Winston Farm, Town of Saugerties, and Village of Saugerties). Additional groundwater exploration, beyond the four wells drilled by LBG (2018), is warranted, including at locations off the Winston Farm property.

Research conducted for this report included the review of well and boring logs from the Winston Farm and Site L (Figure 8) sites, NYSDEC post-2000 well log database, and a number of pre-1995 well logs amassed in 1995 by the Winston Farm Alliance to aid HydroQuest with potential landfill site evaluations. Where exact well and boring locations were accurately identified and well log data was of sufficient quality for use, ground surface elevations were determined using two-foot contour elevational data. This allowed determination of the depth to the top of bedrock below the ground surface, as well as the top of sediment horizons where they are present and noted on well logs.

A subset of the data reviewed and analyzed is portrayed on Figure 17. Numbers adjacent to green triangles and red circles reflect the elevation of the top of the bedrock surface relative to mean sea level (msl) in the year 2022. Positive values next to green triangles are top of bedrock elevations above today's sea level. Negative values next to red circles are top of bedrock elevations below today's sea level. Geomorphically, land surfaces adjust or are ultimately downcut by erosive forces to the lowest possible elevation. Locally, this base level elevation is the Hudson River and the Atlantic Ocean. Negative top of bedrock values presented on Figure 17 provide evidence of stream or river downcutting to a lower, ancestral, level of the Hudson River that developed when the sea level was lower due to massive earth cover by glaciers. With the exception of the Malden Well (purple circle on Figure 17; - 171 feet below msl), the deepest recorded depths to the top of bedrock indicate a southward paleochannel gradient. The great depth to the top of bedrock recorded in a driller's log in the Malden Well either 1) provides evidence of a very deep tributary to an ancestral level of the Hudson River, or 2) indicates a problem with the driller's log.

Dineen et al. (1988) address preglacial channel configuration in eastern New York State. Based on assessment of well logs, engineering data, and other sources, the data illustrate ancestral stream channels formerly graded to a paleo-Hudson River level that was elevationally lower than today. This condition was present during a time when sea level was lower. Channels in the Catskill region were oriented with southeasterly trending flow directions graded into the elevationally lower Hudson River. The Beaver Kill Valley fits into this paleo-flow network as indicated, in part, by substantial widening from north to south, as well as a limited number of boreholes and wells that document bedrock well below today's sea level (Figure 17).


Bedrock Surface Elevations Relative to Mean Sea Level Proximal to and Within Buried Paleo Channels
Proposed Car Wash Site
High Pt Elev: +200 ft msl
Legend
Winston Farm Footprint
Site L
Bedrock Elevations Above MSL
Bedrock Elevations Below MSL
Buried Channel Thalweg (~ partial trace)
Malden Well
N
Figure 17
0 0.25 0.5 1 1.5 2 Miles
HydroQuest Graphic: 4-04-22
West Camp
Eavesport
Malden on Hudson
Malden
Saugerties
Saugerties South
Glasco
Glenerie
Centerville
Veteran
Fish Creek
Ulster County
Route 212
Route 32
Highway 9W
+80
+39
<+67
<+59
+155
+174
+164
<+36
-171
+358
+214
+83
+303
+142
+298
+284
<+51
+40
+153
+365
-12
+24
+59
+280
+19
+180
-58
-70
-37~
+119
-84
+80
+361
+37
+45
+65
+70
+101
-39
-23
+18

In geography and fluvial geomorphology, a thalweg or talweg is the line of lowest elevation within a valley or watercourse. Recognizing that few if any wells exactly encounter the deepest point within the paleo-channel (the thalweg), well data provides evidence that lowest measured points in the buried channel generally fall in the -70 feet below msl to -80 feet below msl range, apparently grading downward to the south. The dashed red line on Figure 17 approximates the pathway of the paleochannel that is now infilled in places with highly permeable sand and gravel aquifer material (aka the Beaver Kill Aquifer) that is overlain by thick glacial lake clays and silts of low permeability. Unconsolidated sediments (sand and gravel) present in the paleochannel thalweg may represent the best location to obtain high aquifer yields as a result of their high permeability, maximum groundwater storage potential, position near the base of the buried valley, confined, aquifer, and interconnection with elevationally-higher sediment horizons.

Details regarding the configuration of the paleochannel which contains sand and gravel deposits comprising the Beaver Kill Aquifer allows projection of much of the channel's form (aka geometry or architecture). This information is of value because it provides a means of roughly assessing the vertical and lateral extent of the aquifer material and provides some of the key information needed for formulation of conceptual site models that can successfully be used in water supply development work.

When the bedrock geology adjacent to buried permeable deposits is known and taken into consideration, this information allows hydrogeologists to constrain and project the linear direction of groundwater influence during aquifer pumping. Figure 7 is a 4000-foot geologic cross section constructed using detailed elevational data of the land surface, observed bedrock structure on the ground surface, well logs, and Site L boring log data. Figure 8 depicts the location of this A to B geologic cross section. As illustrated on Figure 7, aquifer recharge here occurs from the east along dissolutionally enlarged fracture, bedding plane, and conduit pathways in the Onondaga limestone and from the west along fracture pathways in Hamilton Group sandstones and shales, along joint pathways within upper weathered portions of the glacial clay strata, and along valley flank contact zones between bedrock and sediments. The importance of aquifer recharge via the karstic Onondaga limestone is detailed later in this report.

Conceptual Site Model: Winston Farm Area Portion of the Beaver Kill Aquifer

Knowledge of aquifer geometry and sediment stratigraphy should guide well location selection when evaluating potential Village of Saugerties' backup water supply options. This report provides important geologic analyses that can be used by hydrogeologists to help identify target locations likely to support high-yielding water supply wells. This information, when coupled with assessment of other available data (e.g., well logs, hydrologic analysis) provides a powerful tool for use in selecting well sites with maximum yield potential.

Potential supplemental water supply development in the Winston Farm area has been contemplated by the Village of Saugerties. To that end, the Village leveraged substantial funding from the New York State Storm Recovery Office to conduct a groundwater exploration study on the Winston Farm site. This entailed having LBG Hydrogeologic & Engineering Services, P.C. drill and install four 6-inch diameter wells in 2018 on the Winston Farm project site. Each of the four wells were

drilled through thick glacial lake clays and silts (86 to 130 ft) before reaching a highly permeable sand and gravel aquifer above bedrock.

Groundwater found on the Winston Farm site as part of that study could serve as an auxiliary water source in the event the Blue Mountain Reservoir becomes polluted for a short time because of either a natural or man-made disaster (Lambertson, 2021). The resultant LBG Hydrogeologic & Engineering Services report (2018), obtained through a Freedom of Information request, provides four detailed boring/sediment logs (TW-1 to TW-4) that document the depth to the underlying bedrock. This HydroQuest report extracts sediment data from these logs, places it within a larger geologic framework that characterizes the depositional environment, graphically plots subsurface geology, and provides a reasoned hydrogeologic interpretation within the constraints of available geologic, geomorphic, and topographic data. The picture that emerges can then be used to scientifically focus and advance additional water supply exploration. **And, importantly, conceptual understanding of the nature and extent of the Beaver Kill Aquifer and its recharge areas can then be wisely used to ensure that full protection of the Aquifer Protection Overlay District is not compromised by contemplated variances or zoning amendments that risk water quality degradation.**

In terms of potential water supply location and development, it is necessary to grasp how individual wells/borings fit within the physical geometry of the sediment deposits being targeted (i.e., vertical and lateral extent of the aquifer, architecture of the sediment deposits, hydrologic boundaries). To best understand and make use of the four Winston Farm sediment logs, HydroQuest looked well beyond the individual sediment descriptions. This is done by developing a conceptual site model that incorporates data from the individual wells and correlates those findings within a broader physical understanding of how they relate to each other, how they fit in with the geologic setting, how they evolved within the geomorphic history of the area (depositional history), how they may be used to reconstruct the geometry of the water bearing units (i.e., aquifer), and how the resultant interpretation may be used to target additional water supply wells with high safe yields in portions of the aquifer with high groundwater storage capacities.

Additional insight into the configuration of part of the paleo-channel situated beneath the Winston Farm site (different from that illustrated in cross section A to B discussed above) is graphically shown on Figure 18. This plot makes use of geologic/sediment information provided on LBG's (2018) boring logs from locations TW-1 through TW-4, two-foot surficial elevation contours, well location placement using GIS technology and high resolution orthoimagery, and a kriging program to interpolate and develop a subsurface contour map of the bedrock surface between and close to the boring locations. The plot shows 1) the elevation of the bedrock surface relative to today's sea level with yellow labels, 2) the thickness of sand and gravel encountered in each boring with white labels beneath thick glacial clays, and 3) five-foot interpolated elevational contours grading from 59 feet above mean sea level in TW-1 to 12 feet below mean sea level in TW-3. Overall, the plot shows a northeasterly and perhaps easterly sloping bedrock valley floor with substantially thicker permeable sand and gravel horizons downslope closer to the deepest portion of the paleo-channel bottom (thalweg). It is highly likely that the bedrock surface interpolated from these four borings also slopes downward to the southeast. Although boring data is not available in this area, a southeastern slope is indicated by 1) deep bedrock encountered in wells situated southeast of TW-

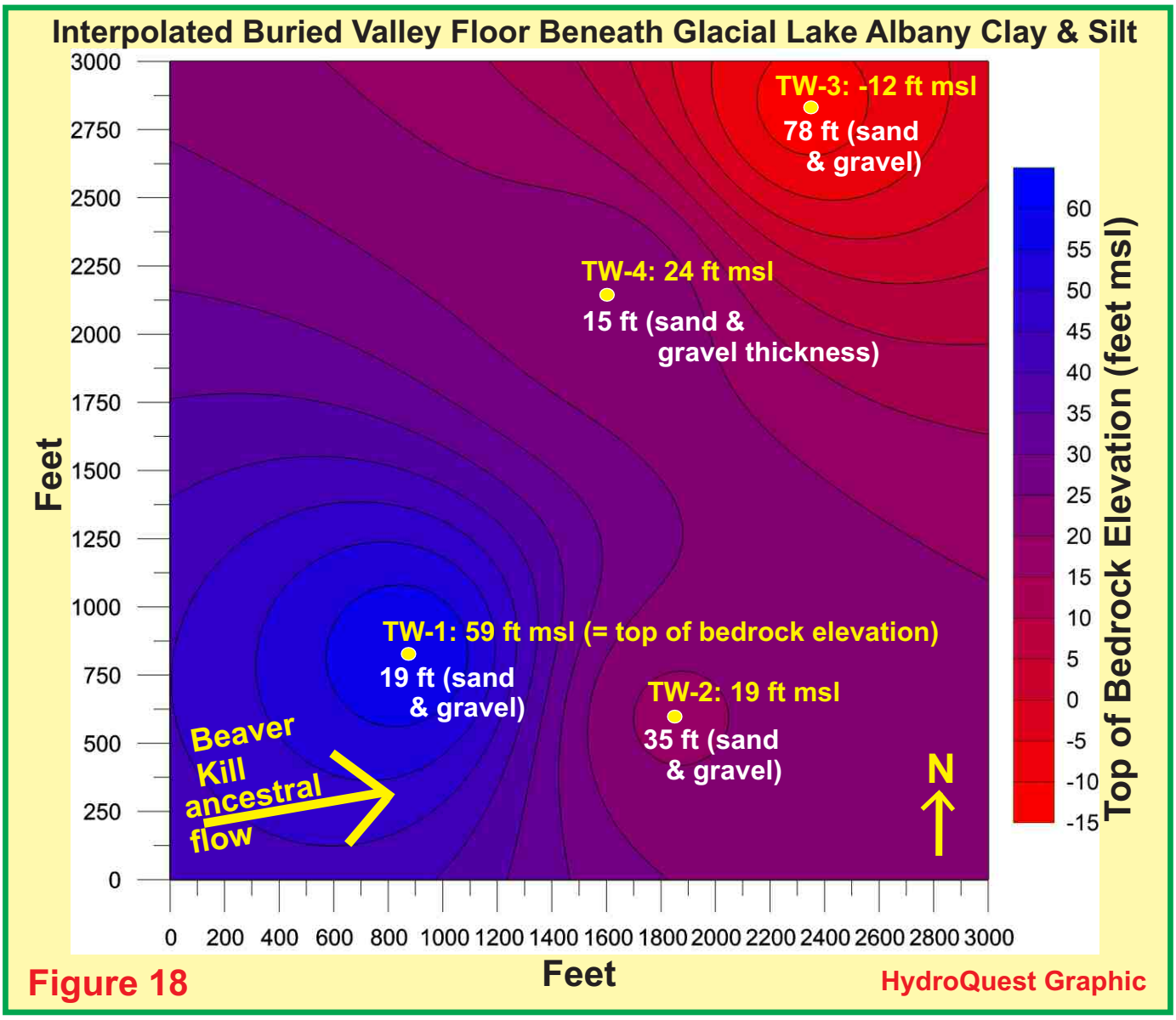


Figure 18

HydroQuest Graphic

2, and 2) HydroQuest's interpreted geomorphic nature of the sediment deposit logged in Winston Farm borings TW-1 to TW-4.

Figure 19 provides an unusual means of visualizing the fan-shaped sediment deposits (sand and gravel) present beneath the TW-1 to TW-4 test wells. Essentially, if one envisions the ancestral stream flow indicated on Figure 17 depositing sediments down the surface of the bedrock slope contoured on Figure 18, descending downward into deep Glacial Lake Albany, they will fan outward - filling the bottom of the paleo-Beaver Kill channel discussed previously. An accumulation of thicker sediments will fill the paleo valley bottom, much like the tapered wedge-shaped form of the inverted bracket fungus, thinning both upward toward the western sediment source and laterally (north and south). Here, the vertical trunk of the birch tree represents the eastern bedrock valley wall that stops sediment accumulation in that direction. Later in time, a thick sequence of clay and silt was deposited on top of the sand and gravel (fungus) deposit. This inverted fungus analogy illustrates varied sediment thicknesses coincident with the easterly influx of sediments and also accents the potential importance of placing production wells in thicker portions of the aquifer (e.g., TW-3) versus thinner, high elevation, portions (TW-1) where the groundwater storage capacity is less. Thus, understanding the physical form or geometry of the aquifer can be important when designing aquifer exploration programs and selecting water supply production well locations. This is particularly true when characterizing the Beaver Kill Aquifer because, unlike many aquifers, it does not extend equally for long distances in all directions.

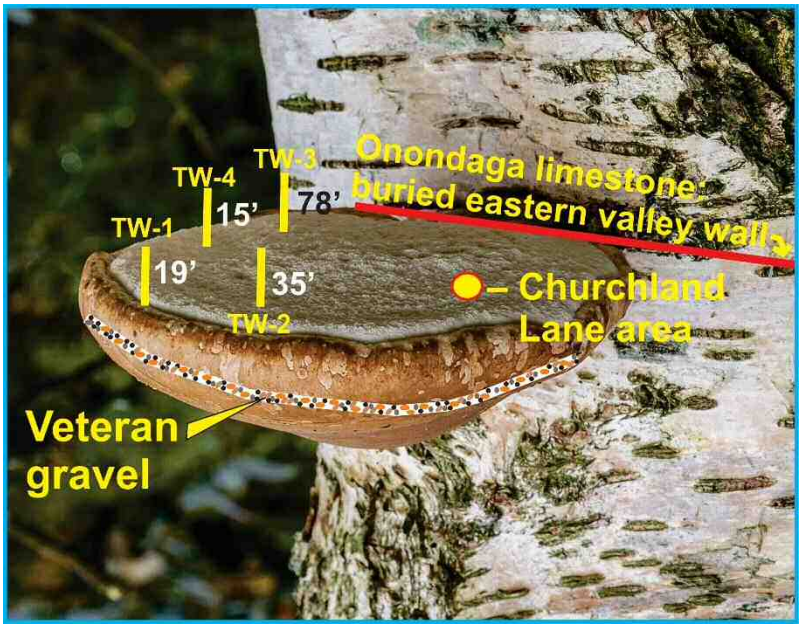


Figure 19. Bracket fungus illustrates the general configuration of the deltaic sediment deposit present beneath the eastern portion of the Winston Farm site. The numbers are the sediment thicknesses in site wells, being thicker in the paleo-valley bottom.

These sediments are part of a westerly-derived delta deposit discharged into the paleo-channel portrayed on Figure 7 and into Glacial Lake Albany prior to being covered with thick clays and silts. Here, a delta is a fan-shaped area of sediment deposited into a standing body of water (Glacial Lake Albany) at the down gradient terminus of a stream. A brief description of HydroQuest's Winston Farm area conceptual site model is as follows. Over millions of years, a deep valley was downcut through bedrock into the weak underlying Bakoven shale (Figure 7). Resistant, westward sloping, Onondaga limestone (Figure 20) thwarted eastward stream flow, as did sandstone beds of the Hamilton Group situated to the west. This ancestral north-to-south trending channel was carved to a depth of at least 70 to 80 feet below today's sea level south of the Winston Farm site and graded to a deeply incised ancestral Hudson River channel to the southeast. Through time, tributary streams developed and flowed eastward off the adjacent Catskill Mountains. One of the largest tributaries incident to the paleo-Beaver Kill channel flowed eastward roughly along the route of the east trending reach of today's Beaver Kill illustrated on Figure 3. Eastward flow along this channel may have incorporated substantial flow from the Plattekill Creek that may now be beheaded (see red lined potential channel flow route on Figure 3). Either way, substantial stream flow occurred into the north to south trending deep channel illustrated in the Figure 7 cross section, as documented by deep wells shown on Figure 17. Another potentially significant tributary to this now buried paleo-channel is reflected by an incised stream channel situated east of the 24-acre wetland and at the center of Figure 4.

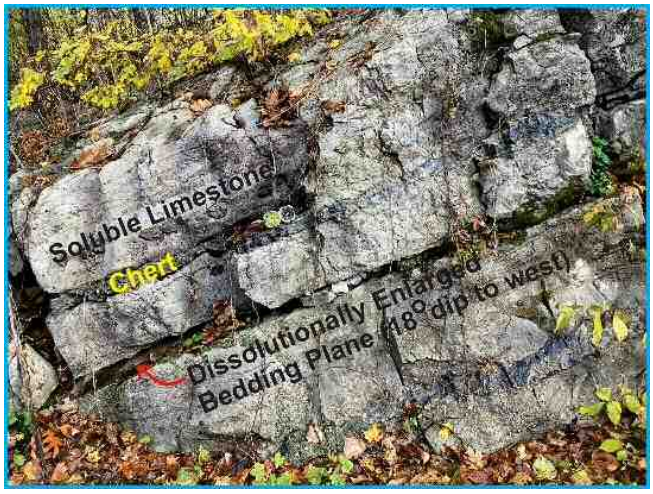


Figure 20. Steep, westerly dipping, Onondaga limestone.

During retreat of the most recent glacier northward up the Hudson Valley, a large glacial lake filled much of the Hudson Valley - locally to an elevation equal to or higher than the 200-foot red line depicted on Figure 4. This was a time of massive sediment influx from the Catskill Mountains into deep Glacial Lake Albany. Initially, fine sand and dark gray silt was deposited onto the eastward sloping valley floor, leaving a limited sediment record just above bedrock in boring TW-3. Figure 21 presents geologic cross section C-to-D that extends north-northeast from TW-1 to the former Baldelli well on Mower Mill Road (see section location on Figure 8). Test wells TW-2 and TW-3 were projected into the section line. Unlike cross section A-to-B that is positioned perpendicular to the Beaver Kill Valley trend, section C-to-D trends generally up and across valley. While the dashed red lines on Figure 21 may not be exactly positioned due to lack of data in the valley center area, a reasoned interpolation and geologic interpretation of the subsurface geology and stratigraphy is presented.

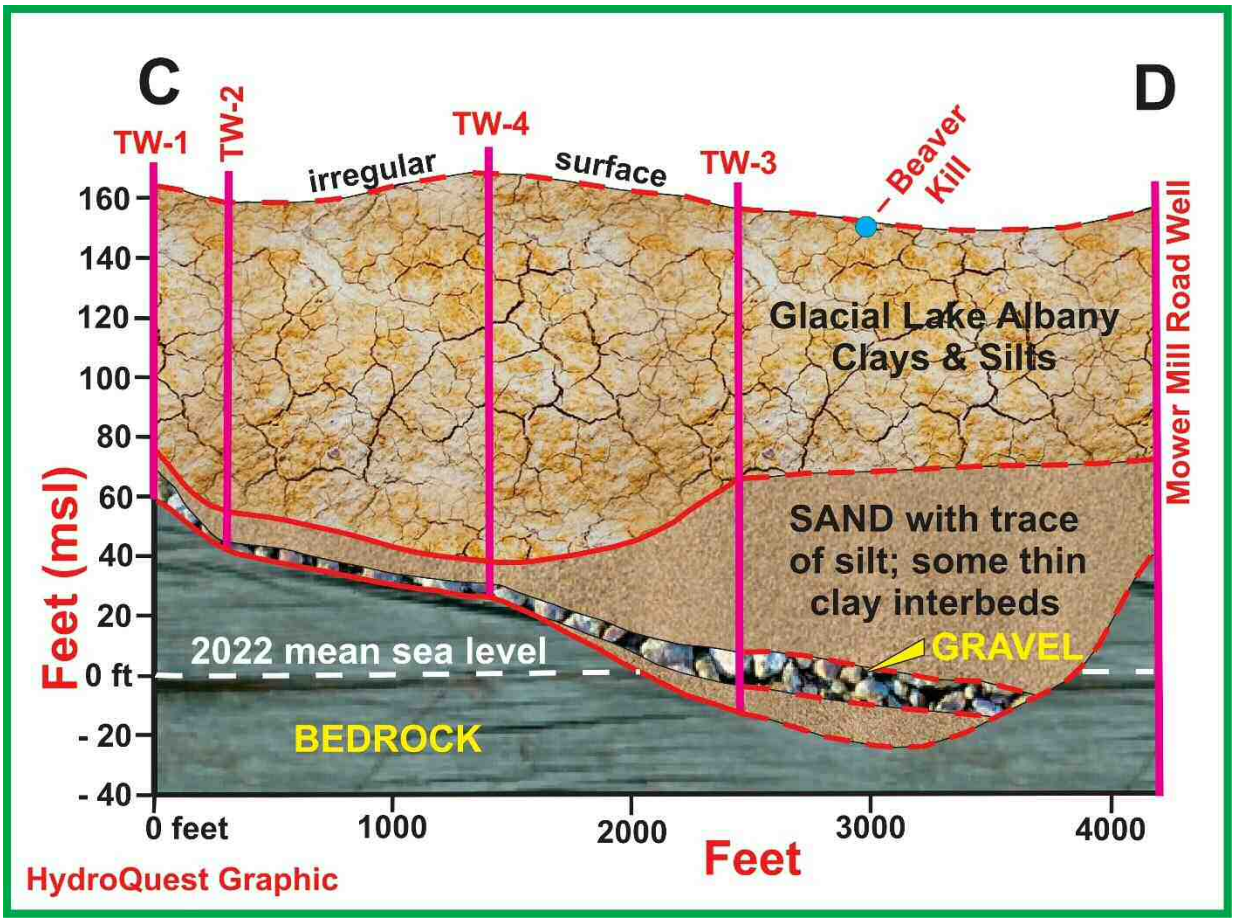


Figure 21. Geologic cross section between Winston Farm well TW-1 and a well on Mower Mill Road. Figure 8 shows the location of the cross section line.

Continuing with a description of the conceptual site model, the gray color of thin silt and clay horizons documented within thick sands in Winston Farm wells tells us that the glacial lake was deep and oxygen poor. Much higher stream discharge followed. This was glacial meltwater stemming from nearby glacier ice, charged with gravel and pebbles. All four Winston Farm boring logs record deposition of this gravel ranging from about 3 feet to 12 feet in thickness locally. This gravel-rich unit serves as an excellent sediment marker bed referred to here as the "*Veteran Gravel*." It appears to be continuous, largely as a down-sloping blanket of highly permeable gravel above the bedrock valley floor. Driller's logs from other area wells also record the presence of gravel and sand below thick glacial lake clays.

Fine sands with some thin, dark gray, clay interbeds overlie the Veteran Gravel. This likely denotes the western recession of glacier ice, now depositing fine sediments into Glacial Lake Albany. The former Baldelli 1988-drilled well along Mower Mill Road encountered 31 feet of sand beneath 86 feet of glacial lake clays and above the Onondaga limestone. In turn, sandy layers are overlain by numerous dark gray clay and silt sediment layers (Figure 21), documenting seasonal, temperature-related, variations in sediment size. These clays and silts indicate further

retreat of Catskill Mountain glacier ice, now only delivering very fine sediments far out into Glacial Lake Albany. Only the uppermost clay layers are recorded as being dark brown in color, the color change reflecting weathering above the water table of the upper portion of the sediment sequence, resulting in oxidized sediment. These lake or lacustrine clay-rich deposits range in thickness from 86 to 130 feet in borings TW-1 and TW-4, respectively. Elsewhere, they range from absent, to a few feet, to over 200 feet in thickness.

Beaver Kill Aquifer and Winston Farm Well Yields

The NYS SEQRA Full Environmental Assessment Form (FEAF), Part 2, Section 4 (Impact on groundwater) is designed to assess if a proposed action may result in new or additional use of groundwater, or may have the potential to introduce contaminants to groundwater or an aquifer. Several items in this section require detailed evaluation:

> "*a. The proposed action may require new water supply wells, or create additional demand on supplies from existing water supply wells.*
> *b. Water supply demand from the proposed action may exceed safe and sustainable withdrawal capacity rate of the local supply or aquifer.*
> *h. Other impacts:* _____ " Potential impact to offsite wells.

The Winston Farm development projects a daily water demand of 373,980 gpd (260 gpm)[Winston Farm Full EAF, Part 1; Section D.2. (Project Operations) Sub-section c.i.] and states that the district or service area is the Village of Saugerties Water System and that the project includes the construction of a new well to provide a redundant water supply source for the water district. No detailed information is provided to document the stated water demand.

LBG Hydrogeological & Engineering Services conducted a 24-hour aquifer test in 2018, using well TW-1 as a production well and the three other wells as monitoring wells. At the end of this aquifer test, conducted at a flow rate of 110 gallons per minute (gpm), the pumping water level did not reach stabilization in accordance with NYSDOH criteria that is considered acceptable for development of public water supplies. To address this issue, LBG conducted a detailed hydrogeologic analysis to estimate aquifer parameters and the potential theoretical yield of a production well using hydrogeologic methods. Based on a number of assumptions, they estimate that the aquifer beneath the Winston Farm property can produce some 251 gpm to 194 gpm based on 30-day and 180-day projections. This quantity may not be sufficient to meet peak project water demand.

In LBG's discussion of Theoretical Yield Assessment, they "*Note, these yield estimates are based on the 24-hour yield test conducted and* ***assume that no boundary conditions are encountered*** *in the aquifer during a period of longer duration pumping in the well*." (Emphasis added) LBG also states: "***The pumping water level in TW-1 did not reach stabilization*** *in accordance with New York State Department of Health (NYSDOH) Part 5, Subpart 5-1, Appendix 5-D criteria during the 24-hour test.*" (Emphasis added) As documented in this report, bedrock valley walls are hydrogeologic boundary conditions. Thus, two key conditions examined when seeking to construct wells for a water supply have not been met. Also, Part 5, Subpart 5-1 (State Sanitary

Code), Public Water Systems - Appendix 5D, Well Yield and Water Flow states that before being out into use, new public water supply wells shall be tested for yield as specified in that section. Item e. of the section states: "*The test shall be conducted at a pumping rate at least equal to the design pumping rate based on system demand*." While the Beaver Kill Aquifer at TW-1 may be able to maintain a yield of 110 gpm, or more, this has not been proven. Similarly, the pumping rate during the 24-hour test was less than half of the projected daily water demand of 260 gpm (which has not been detailed). Clearly, testing conducted to date on well TW-1 does not provide sufficient empirical data upon which to establish a public water supply. Additional testing is recommended.

Extended aquifer pumping and drawdown may affect offsite water supplies, primarily those to the south of the project area along Route 212, but possibly some to the north as well. Because of the type of aquifer present, a strip aquifer with east-west bounding bedrock walls, the NYSDOH may require 72-hour testing before approving a Winston Farm production well for use as a public water supply (assuming that this has not already occurred). Based on analyses presented in this report, 72-hour aquifer testing is recommended along with offsite well monitoring of some wells found to be completed within the Beaver Kill Aquifer (see Figure 8 for locations of potential monitoring wells situated both south and north of the green oval). **Notably, other Winston Farm locations, other than TW-1, and off-site locations may have higher safe yield potentials. Additional exploration is recommended in efforts to maximize future water availability for the Village of Saugerties.**

A number of factors should be considered when targeting and evaluating potential water supply sources within the Beaver Kill Aquifer. Many of these have been discussed above. Others are addressed below. Key points include:

- Many boreholes and wells encountered no sand and gravel above bedrock and below clay layers, documenting that most buried valley aquifer material is found within or close to the paleo-valley bottom or invert (aka thalweg);
- Areas of unusually thick sand and gravel deposits within the buried valley Beaver Kill Aquifer reflect relict deltaic material deposited into an early stage of Glacial Lake Albany;
- Some areas of the paleo-valley bottom may have a thin or limited vertical and lateral extent of sand and gravel material (e.g., Figure 7), thereby accenting the need to conduct comprehensive 72-hour aquifer testing prior to committing potentially areally-limited high-yielding sections of the Beaver Kill Aquifer to a limited number of users. It should be noted that the NYSDOH only requires 24-hour testing of unconsolidated aquifers when wells are situated greater than 200 feet from surface water. The bedrock boundary conditions documented in this report and the lack of stabilized drawdown during the 24-hour test conducted of TW-1 justify longer duration aquifer testing;
- Because permeable buried valley aquifer material is predominantly found in the paleo-valley bottom and because its lateral (east and west) extent is constrained by bedrock walls or glacial lake clays (Figures 7 and 21), the direction of pumping influence (i.e., drawdown) in wells will extend in a north-south direction, roughly

in a narrow oval configuration, as is reasonably inferred by HydroQuest on Figure 8 that shows the measured change in water levels in Winston Farm wells documented during an aquifer test as extending along a north south orientation;

- As seen in the geologic cross sections, potential expansion of the area influenced by groundwater pumping will be limited in east and west directions by either glacial clays or bedrock (i.e., boundary conditions). Thus, again, longer-duration aquifer testing is recommended to assess the full extent of pumping influence and the safe yield of the buried sand and gravel aquifer;

- Northward projection of the light green 0.90-foot drawdown oval depicted on Figure 8 accents that 1) the outer boundary of aquifer drawdown during the 2018 Winston Farm aquifer test extends an unknown distance further northward, 2) the close proximity of the proposed car wash site, and 3) the ready groundwater pathway for stormwater or chemical-rich contaminants to reach the proposed TW-1 Winston Farm production well through either natural southward groundwater flow or more rapid induced infiltration from a southern production well into the broad area of pumping influence;

- Outward projection of the groundwater drawdown ovals indicates that wells situated both south and north of the proposed Winston Farm production well (TW-1) may be adversely affected by continuous, long-term, high yield groundwater withdrawal (see locations of *Nearby Houses & Buildings* on Figure 8). Thus, future aquifer testing should determine which offsite wells may be impacted by extended aquifer pumping and should then monitor them during a 72-hour aquifer test. This requires assessment regarding which, if any, of these wells are completed above bedrock within the Beaver Kill Aquifer;

- The foresight and value of having established and fully enforcing regulations designed to protect groundwater resources in the Town of Saugerties is highlighted when referring to Figure 8 which shows the relationship between a proposed car wash site and its southward contaminant flow direction directly downgradient into the zone of pumping influence of the proposed Winston Farm production well. Any contaminant excursion from the proposed car wash site, whether they stem from stormwater discharges, spills, or other releases would pose a water quality threat to proposed downgradient aquifer production wells, whether they are on the Winston Farm site or elsewhere. This figure provides an excellent graphic example showing the need to strictly enforce all existing Aquifer Protection Overlay District prohibited land uses, without exception. This is discussed further in the January 2022 HydroQuest companion report;

- Assessment of water rights should be factored into determinations to apply for a Water Withdrawal Permit that is designed "*To conserve and develop the waters of the state for all beneficial uses for the public*." (i.e., NYS DEC Water Withdrawal Permits are required for water withdrawal with a designed capacity of 100,000 gallons per day or more); and

- Future water supply exploration for the Village of Saugerties would greatly benefit from consideration of the sediment sequence stratigraphy, aquifer geometry, and conceptual site model material presented in this report. Exploration for high-yielding well sites need not be limited to the Winston Farm property.

Recharge to the Beaver Kill Aquifer Through the Onondaga Limestone that Extends Southward from Katsbaan Past the Winston Farm Site

Karst features present along the eastern flank of the buried valley (i.e., dissolutionally enlarged joints, bedding planes, faults, sinkholes, and conduits) provide important pathways for infiltrating surface water that recharges the buried valley aquifer a short distance to the west and some 200 feet lower (Figure 7). These features are vulnerable to pollution because they can provide for rapid transport of contaminants with groundwater over relatively long distances if they are exposed to a source of contamination.

Figure 7 illustrates the principal hydraulic vectors through which surface water infiltrates into the subsurface and recharges the Beaver Kill Aquifer. A very important component of recharge to the Beaver Kill Aquifer occurs through the well-karstified Onondaga limestone. The nature of this carbonate aquifer is discussed by HydroQuest in the companion report dated January 8, 2022. This report was commissioned by the Town of Saugerties' Planning Board.

While the discussion provided in the January 2022 HydroQuest report on karst hydrology (e.g., pages 9-11, 18-19, 21) is explicit and directly applies to the area west of Route 32 that extends from Katsbaan to and beyond the proposed Winston Farm site, additional documentation is provided here. Foremost, HydroQuest provided key hydrogeologic documentation to the Town of Saugerties in the 1990s of the karstic nature of the Onondaga limestone in the Site L and southward extending area that was instrumental in thwarting development of a regional mega-dump west of Route 32. Scientific information was provided regarding the karst terrain present there that was non-speculative, generalized and conclusory.

Reference to the geologic cross section depicted on Figure 7 correctly illustrates the Onondaga limestone steeply sloping or dipping westward west of Route 32. Figure 20 is a photograph that shows this westerly dip of the limestone beds. Palmer (2007) and karst hydrologists throughout the world recognize that surface water infiltrating downward into both gently and steeply dipping carbonates will faithfully follow bedding planes, fault planes, and joints as they descend to underlying aquifers. West of Route 32, inclusive of the proposed car wash site, the limestone beds dip steeply westward. Groundwater in the Onondaga limestone situated west of Route 32 in the area being addressed here will flow down the steeply dipping limestone partings to the west to the Beaver Kill Aquifer. This is illustrated on Figure 7. Note, also, on Figure 7 that the shaly limestone of the Schoharie Formation and shale and siltstone of the Esopus shale lie to the east. <u>These shale-rich bedrock formations preclude groundwater flow to the east - groundwater flow in the Onondaga limestone west of Route 32 is to the west toward the lower elevations present in the Beaver Kill Valley.</u> Instead, all surface water infiltrating into the underlying Onondaga limestone in the area being addressed MUST flow downgradient to the west. Also illustrated on the Figure 7 geologic cross section is the approximate 200 feet of elevation decrease from the Route 32 area downward

to the underlying Beaver Kill Aquifer. As clearly illustrated on Figures 7 and 20, the steeply west-dipping Onondaga limestone can only transmit groundwater in a westerly downgradient direction. **Therefore, based on the structural and karst geology present as documented in this report by field-based bedrock dip and strike measurements and photographs, the Aquifer Protection Overlay District correctly includes the land area west of Route 32, inclusive of the proposed car wash and Winston Farm project areas. As illustrated on Figure 7, the Onondaga limestone here is a significant contributor of recharge to the Beaver Kill Aquifer.**

The NYRWA (2005) concurs with this assessment. For example, on page 28 of the NYRWA's report, the following statement is made: "*The highest potential rates of ground water recharge areas for bedrock generally occur in areas where soluble limestone bedrock is at or near the land surface.*" Figure 29 of the NYRWA's report illustrates this Route 32 shallow limestone area of preferential ground water recharge in pink coloration. HydroQuest shared the January 8, 2022 companion report commissioned by the Town of Saugerties with the author of the NYRWA's 2005 report (Hydrogeologist & Source Water Protection Specialist). The review response was: "*Very, very thorough report!"*

While the information provided above is definitive and would be supported by karst and structural geologists anywhere throughout the world, additional documentation of the karstic nature of the Onondaga limestone here is presented below.

Dissolutionally enlarged bedding planes, joints, and faults provide important groundwater flow vectors within the Onondaga limestone. Examples of these features are illustrated below on Figures 22 and 23. Fault planes present within the Onondaga limestone provide preferential pathways for infiltrating surface water and snowmelt to recharge the buried valley aquifer along the eastern flank of the Beaver Kill Valley (Figure 23).

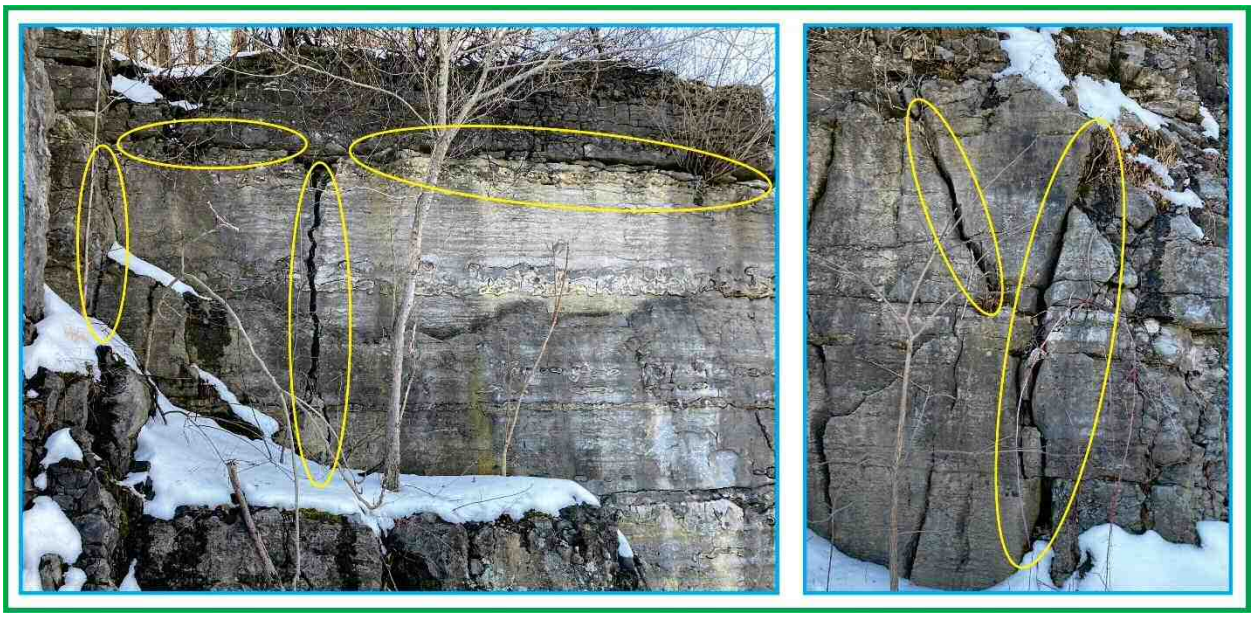


Figure 22. Dissolutionally enlarged joints and bedding planes (yellow ovals) in Katsbaan exposures of the Onondaga limestone. These features and solution conduits provide recharge pathways from the east side of the Beaver Kill Valley down the slope or dip of the limestone to the valley bottom some 200 or more feet lower. As discussed in the HydroQuest companion report, limestone or karst aquifers are extremely vulnerable to contaminant inputs. The nearby 1936 State Education Department plaque refers to the "Indian Cave" here, home of "Nachte Jan", that may have been removed by Rt. 32 road construction.

Figure 23. Two Katsbaan examples of slickensided fault planes that cut across bedding in the Onondaga limestone. Slickensides are polished and striated rock surfaces that result from friction along a fault or bedding plane. The fault plane above (left) dips 35 degrees to the northwest, cutting across bedding, trending westward toward the buried valley. This is an example of a preferentially permeable pathway in a karst setting along which aquifer recharge occurs. These features document the importance of strictly maintaining existing Town of Saugerties regulations designed to protect groundwater quality in the Aquifer Protection Overlay District.

Figure 24 provides sketched and measured cross sections of solution conduits observed within the Onondaga limestone along the Route 32 corridor area discussed in this report. Conduits in limestone have the highest permeabilities of all aquifer types. Even very small conduits (less than finger sized) exhibit rapid, turbulent, flow as compared to slow, laminar, flow in other common aquifer settings. The transition takes place at joint widths of about 0.5 – 1 centimeter, depending on the hydraulic gradient and temperature (Palmer, 2007). These conduits provide direct proof of the karstic nature of the Onondaga limestone present along the Route 32 corridor and west of it. Conduits such as these can form in less than 10,000 years. Because the buried valley situated west of Route 32 was present long before it was infilled with glacial sediments, these conduits almost certainly extend to the paleo-valley floor, having formed downward along very steep hydraulic gradients.

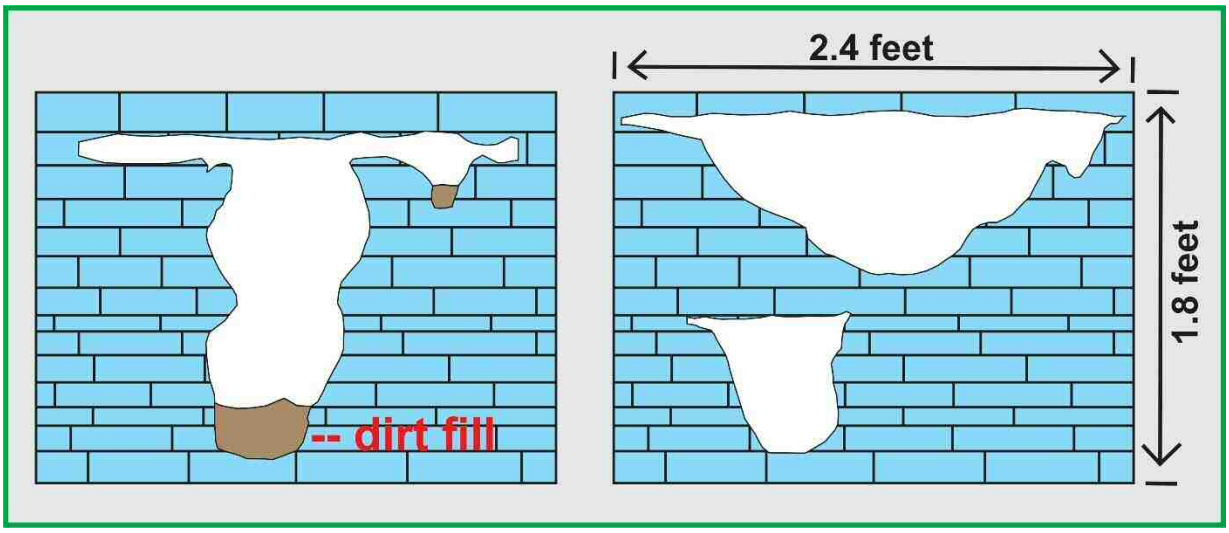
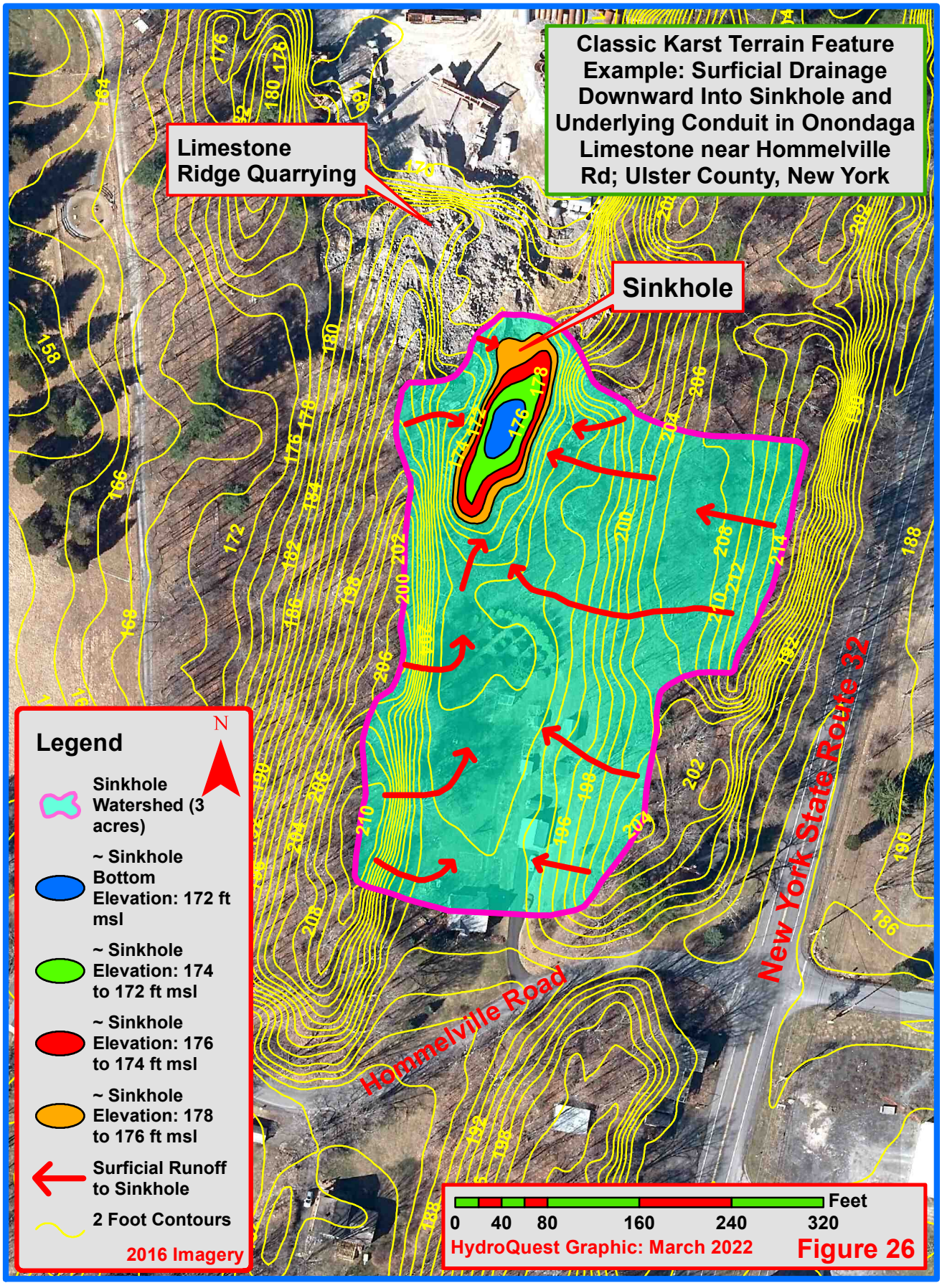


Figure 24. Sketched and measured cross sections of solution conduits observed within the Onondaga limestone karst setting along the eastern flank of proposed mega-dump Site L on 4/26/95 in Katsbaan by Paul Rubin (HydroQuest). Bedrock slopes or dips here at 13° NW towards the buried Beaver Kill Aquifer. While visible solution conduits like these, sinkholes, and caves provide direct irrefutable evidence of well-karstified carbonate bedrock, many karst aquifers exhibit no surficial features at all. Movement of groundwater in solution conduits, like flow in open pipes, is rapid (to miles/hour) with little or no natural cleansing.


Classic Karst Terrain Feature Example: Surficial Drainage Downward Into Sinkhole and Underlying Conduit in Onondaga Limestone near Hommelville Rd; Ulster County, New York
Limestone Ridge Quarrying
Sinkhole
Legend
N
Sinkhole Watershed (3 acres)
~ Sinkhole Bottom Elevation: 172 ft msl
~ Sinkhole Elevation: 174 to 172 ft msl
~ Sinkhole Elevation: 176 to 174 ft msl
~ Sinkhole Elevation: 178 to 176 ft msl
Surficial Runoff to Sinkhole
2 Foot Contours
2016 Imagery
Hommelville Road
New York State Route 32
Feet
0 40 80 160 240 320
HydroQuest Graphic: March 2022
Figure 26

The conduits illustrated above are far larger that finger-sized conduits. They can rapidly transmit contaminants downgradient much like flow in surface streams. There is evidence that even larger conduits developed in the Onondaga limestone along this same corridor in Katsbaan. Figure 25 depicts a 1936 State Education Department plaque that refers to the "*Indian Cave*" here, home of "Nachte Jan", that may have been removed by Rt. 32 road construction. In 1995, a local resident who had been in this cave as a youth recalled its small entrance hole that opened up to dimensions of at least four feet across to a dry room area.

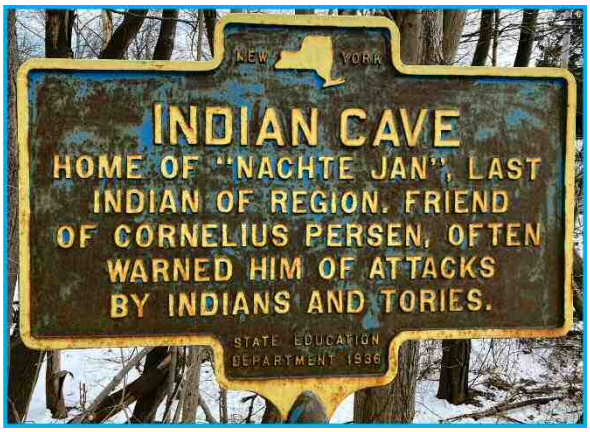


Figure 25. Indian Cave plaque commemorates Nachte Jan who lived in a cave in the Onondaga limestone near the curve in Route 32 in Katsbaan. In 1995, a local resident informed HydroQuest that Route 32 road work covered and may have destroyed the cave that Nachte Jan lived in.

Another classic karst feature present along the Route 32 corridor are sinkholes. The locations of some of them are plotted on Figure 8. Sinkholes funnel surface water into conduits within karst aquifers. As groundwater dissolves the surrounding limestone conduits carry away sediments, dissolved limestone, groundwater, and any contaminants that may be within the water. Even where site access is not available, sinkholes can be discerned by examining detailed contour elevation maps. Figure 26 provides an example of a sinkhole near Hommelville Road and its surrounding watershed plotted by HydroQuest. It is located along the same section of Onondaga limestone as the proposed car wash site and a portion of the Winston Farm site. The red arrows depict surface flow that it is pirated into one or more conduits within the Onondaga limestone. Sinkholes transport water rapidly and directly into karst aquifers.

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Figure List

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Highlighted Conclusions from the HydroQuest Hydrology and Land Use Report of April 2022

- Stormwater, spills, or retention pond infiltration that might be released from the proposed car wash property have a high likelihood of migrating downward into the underlying karst aquifer and the Beaver Kill Aquifer. In less than 2,000 feet, contaminants would either directly flow into or be drawn into the zone of pumping influence of the proposed Winston Farm production well TW-1 (Figure 8);
- The foresight and value of having established and fully enforcing regulations designed to protect groundwater resources in the Town of Saugerties is highlighted when referring to Figure 8 which shows the relationship between a proposed car wash site and its southward contaminant flow direction directly downgradient into the zone of pumping influence of the proposed Winston Farm production well. This figure provides an excellent example showing the need to strictly enforce all existing Aquifer Protection Overlay District prohibited land uses, without exception. This is discussed further in the January 2022 HydroQuest companion report;
- HydroQuest's hydrologic analysis of the 2018 Winston Farm LBG 24-hour aquifer test shows that it should not be relied upon because A) it assumes there are no hydrogeologic boundary conditions, which this report documents and portrays in two geologic cross sections, B) the pumping water level in TW-1 did not reach stabilization in accordance with New York State Department of Health NYSDOH) Part 5, Subpart 5-1, Appendix 5-D criteria during the 24-hour test, and C) the test was not conducted at a pumping rate at least equal to the design pumping rate based on system demand. HydroQuest recommends additional hydrologic exploration and testing, inclusive of locations off the Winston Farm site;
- The Town of Saugerties should consider whether they wish to permanently dedicate the Winston Farm development project's anticipated water demand of 373,980 gpd (260 gpm) to a single, private, commercial project versus for expanded growth throughout the Town for many users. A change in existing zoning to a Planned Development District - Winston Farm would essentially be an acknowledgement of preferred private commercial water use;
- Consideration of zoning changes to one with a higher water demand should be predicated on full documentation of needed and available water supply. It would be premature to consider a zoning amendment without assurance of an adequate water supply;

- Future exploration for a Village of Saugerties' backup water supply would greatly benefit from consideration of the sediment sequence stratigraphy, aquifer geometry, and conceptual site model presented in this report. Exploration for high-yielding well sites need not be limited to the Winston Farm property;
- Notably, other Winston Farm locations, other than TW-1, and off-site locations may have higher safe yield potentials. Additional exploration is recommended in efforts to maximize future water availability for the Village of Saugerties;
- Consideration of zoning amendments to one with a higher water demand should be predicated on full documentation of needed and available water supply. It would be premature to consider a zoning amendment without assurance of adequate water supply;
- A large (24-acre) NY State wetland partially on the Winston Farm site and its HydroQuest delineated watershed would have substantial development nearby and over it, respectively. This may disrupt the hydrologic fluxes that make the wetland healthy and viable;
- Significant recharge to the Beaver Kill Aquifer occurs through much of the proposed Winston Farm project site. Hydrogeologic assessment provided in this report should be considered when reviewing proposed project development;
- Assessment of water rights should be factored into determinations to apply for a Water Withdrawal Permit that is designed "*To conserve and develop the waters of the state for all beneficial uses for the public*." (i.e., NYS DEC Water Withdrawal Permit for water withdrawal with a designed capacity of 100,000 gallons per day or more);
- Additional characterization of the Beaver Kill Aquifer is warranted through a combination of well log compilation and analysis (from drillers, NYSDEC and other sources); reanalysis of old aquifer tests, new carefully-logged boreholes, sediment sequence stratigraphy, geophysical transects (possibly), new aquifer testing, and hydrogeologic analysis; and
- Long-term water quality protection within the 7000^{+}-acre Town of Saugerties' Aquifer Protection Overlay District would be best accomplished by strongly supporting preservation of all existing regulations.