Groundwater Report

Town of Philipstown Groundwater Report and Planning Resource

Town of Philipstown
Putnam County, New York

June 2007

THE Chazen COMPANIES

Prepared for:

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EXECUTIVE SUMMARY

The Town Board of the Town of Philipstown retained The Chazen Companies (TCC) to review groundwater relationships in the Town. The work scope for this study was defined during meetings held in early 2006 by a project team consisting of community residents and Town Board liaisons. Development of aquifer planning recommendations was a recommendation of the Town's Comprehensive Plan, and justified since a majority of Philipstown residents and many businesses use groundwater as their primary water source. Only residents in Cold Spring and residents in parts of Nelsonville and Continental Village use water from surface water reservoirs.

Various reference groundwater maps are provided in this report. Plate 1 shows aquifer boundaries, watershed boundaries, estimated watertable contours, and groundwater flow arrows identifying directions of groundwater migration. Plate 1 is designed to help visualize aquifer conditions throughout the town. Figure 5 shows areas with different aquifer recharge rates throughout the Town. Over 90 percent of the town has either silty soil which allows annual infiltration of 7.6 inches of aquifer recharge or sandy soils which allow 14.7 inches of annual aquifer recharge. Plate 2 is a draft aquifer boundary map showing the extent of the bedrock aquifer under all of Philipstown, Cold Spring and Nelsonville. Plate 2 also identifies the boundaries of a sand and gravel aquifer near the Clove Creek. Plate 2 may be used as an overlay layer map in town zoning.

Minimum lot size recommendations are provided for areas where individual septic systems and individual wells will continue to be used. For 90 percent of the Town, the recommended minimum average parcel sizes are between 1.6 and 3.0 acres. Figure 7 identifies areas where existing parcels may already be undersized. Conceptual approaches for improving wastewater treatment in such areas or in other areas with high concentrations of septic systems are reviewed in Appendix B.

The report includes recommended levels of aquifer protection for different aquifer areas in Philipstown. These are generally consistent with groundwater management recommendations provided in Putnam County's 2004 groundwater planning study, also prepared by the Chazen Companies. Hydrogeologic factors governing groundwater availability in Philipstown are summarized here:

- Aquifers underlie all parts of Philipstown. These include a sand and gravel aquifer extending under the northern portion of Route 9 near the Clove Creek, and a bedrock aquifer underlying the entire town. These aquifers offer the only ready source of water to many residents and so warrant protection and/or planning management.

- In general, adequate groundwater is available in Philipstown to support most present and future water requirements. However, groundwater resources can be locally overtapped, either by over-extraction from wells, or by overloading local aquifer areas with septic system discharges or road salt residues.

- The varied topography in Philipstown isolates segments of the bedrock aquifer into discrete subwatershed areas, such as those around the Indian Brook, Philipse Brook, Arden Brook, Clove Creek and Canopus Creek. Although a generally common bedrock aquifer extends across the entire Town, groundwater in these separate watersheds does not mix and cannot be readily moved from one watershed to another, allowing the possibility of local over use or local contamination which cannot be relieved by, or will not cross-contaminate, groundwater in adjacent watersheds.

- Expanded future water demand can be readily accommodated in Philipstown, but wells may need to be spread over wider areas to ensure that sufficient aquifer recharge areas are available to support each new well. Site specific well testing is warranted for higher water use wells.

- Groundwater quality degradation from septic systems is a form of groundwater over-use if waste constituent concentrations impair drinking water quality.

- Philipstown has higher density areas, including commercial and residential centers, and both moderate and low-density areas. Where groundwater is the principal source of water supply, different groundwater management strategies are recommended for the high and the lower density areas.

- Federal and State environmental regulations passed since the 1970s, as well as growing availability of improved remediation techniques, have significantly reduced groundwater threats from point sources such as gas stations, dry cleaners, and heavy industry activities. Although the enforcement of groundwater protection regulations applicable to such uses continue to be a concern, outright prohibition of such land uses may be warranted only in highest-risk aquifer areas. Such highest-risk areas could be defined on the basis of aquifer capacity, highly settled areas, or in recharge areas for central water supply wells.

- Septic systems represent a wide-spread and potentially-significant source of non-point aquifer contamination. Contaminants from septic systems include not only compounds with existing regulatory standards such as for nitrate or *e*-coli, but also include more recently recognized constituents such as caffeine, pharmaceutical residues, and hormone residues, for which no standards yet exist. The reliance on aquifers to both provide potable water to wells, and to receive and dilute septic system wastes requires an active management strategy.

- Existing Health Department pumping test procedures for proposed Community Water System wells (e.g. water districts using central wells) are generally adequately rigorous and only warrant off-site impact oversight under SEQRA by municipal planning board. However, aquifer testing required for new subdivisions using individual wells is not as thorough. As part of SEQRA review processes, municipal planning boards are encouraged to require evaluations of the combined discharges of pre-drilled individual wells in such proposed subdivisions for at least 24-hours.

- Installation of small sewage treatment districts has become increasingly cost effective. New technologies include small diameter piping systems, opportunities for solids retention on individual parcels, and package scale treatment plants for districts with limited users and even for individual septic systems. Regulations are periodically being revised in ways which make many non-traditional and decentralized wastewater treatment systems increasingly feasible. A review of such options and management structures is found in Appendix B.

- Road salt and water softener salts are non-point contaminant sources affecting groundwater and stream quality. Road salt application rates and snow/salt accumulation areas should be actively managed.

- Because of the current use levels and aquifer vulnerability to contamination, a high level of groundwater protection is recommended for the Clove Creek sand and gravel aquifer found along the northern Route 9 corridor. A more flexible level of aquifer protection is recommended for the bedrock aquifers underlying the rest of Philipstown. If new public water system wells are installed anywhere in the town, aquifer protection should be provided to wellhead recharge areas.

- In most cases, installation of central sewerage is a preferred remedy for areas where septic systems have impacted groundwater quality since wastewater treatment will improve both well water quality and general groundwater and adjacent surface water quality.

- Proposed projects should evaluate whether they are self supporting. A method is presented which may be used to determine if proposed water consumption is balanced by natural recharge. Credits for enhanced recharge and/or low-impact development techniques can be part of this methodology. Self-supporting projects are preferred and less SEQRA review needs to be required for such sites.

1.0 INTRODUCTION

In response to Town of Philipstown planning initiatives and groundwater concerns, the Town Board of the Town of Philipstown assigned a groundwater working group in 2006 to review and prioritize groundwater concerns relevant to the Town's comprehensive planning processes. This group met during 2006 with a hydrogeologist from The Chazen Companies to review existing groundwater information and identify missing information. The process identified specific information needed by the Town to assist or resolve planning objectives. These tasks were authorized for investigation by the Town Board and are the subject of this report. The groundwater needs identified by the committee included the following:

- Aquifer data. The Town would benefit by possessing an aquifer map, supportive general text, and planning recommendations. The aquifer map should show approximate aquifer boundaries, directions of groundwater flow, and probable depths of groundwater below grade. The accompanying aquifer report should describe recharge rates, aquifer characteristics and provide water resource planning recommendations and a model aquifer protection aquifer which could be modified for use in Philipstown.

- An aquifer boundary map. If the Town is to adopt an aquifer protection regulation, it will need an aquifer boundary map.

- Groundwater quality data: The Town will benefit from a review of any new available groundwater quality data from aquifers.

- Wastewater Planning. The Town would like to know whether wastewater treatment options exist for community areas too small or rocky for easy installation of traditional sewage collection and treatment systems.

Plate 1 and Sections 2.0 through 4.0 of this report address the need for a town aquifer map, with supportive aquifer descriptions and planning recommendations. A model aquifer protection ordinance developed for the Town of Amenia, NY, and potentially applicable for the Town of Philipstown is found in Appendix C. Plate 2 provides a draft aquifer overlay map. Groundwater quality data are described in Section 3.0 and Appendix A. Wastewater management options are described in Section 4.0 and Appendix B. Many of the planning strategies in this report and portions of the format of this report are consistent with regional aquifer management recommendations prepared for Putnam County by The Chazen Companies (Chazen, 2004).

2.0 PHILIPSTOWN HYDRO-GEOGRAPHY

A wide range of geographic factors influence aquifers and aquifer management strategies available to communities such as the Town of Philipstown.

2.1 Setting, Population, Water & Sewer Service

Philipstown lies in western Putnam County, bounded to the west by the Hudson River and to the east by the Towns of Putnam Valley and Kent. Philipstown has an area of approximately 49 square miles, including the incorporated Villages of Nelsonville and Cold Spring (Figure 1). The 2000 census reports a Philipstown population, including Nelsonville and Cold Spring, of approximately 9,400.

Of these 9,400 residents, approximately half rely on groundwater as their sole source of potable water. The other half reside either in the Village of Cold Spring or parts of the Village of Nelsonville relying for water on a local water reservoir with a reported tap into the New York City's Delaware Aqueduct, or reside in those parts of Continental Village drawing water from New York City's Delaware Aqueduct, respectively (TCC, 2004). None of Philipstown lies within watersheds controlled or managed as part of New York City's water supply.

Population centers in Phillipstown lie along transportation corridors and the Hudson River. Larger centers include the Villages of Cold Spring and Nelsonville, the residential area around Cortlandt Lake (Continental Village), and a commercial and residential region following along the northern third of NYS Route 9, extending to the Dutchess County boundary within a broad valley containing the Clove Creek.

The Village of Cold Spring has a sewer system for wastewater collection and treatment. No other wastewater treatment systems of significant size exist in the Town of Philipstown or in the Village of Nelsonville. Cold Spring, parts of Nelsonville and parts of Continental Village receive water from surfacewater reservoirs or water taps into New York City's water supply aquaduct.

2.2 Topography

Philipstown's landscape is characterized by mountainous ridges typical of the Hudson Highlands physiographic province. Ridge elevations rise to over 1,400 feet above mean sea level (asl). Lands adjoining the Hudson River drop abruptly to sea level. Valleys between the upland areas trend north-eastward as a series of small linear valleys throughout the Town. One of the more significant linear valleys extends northward from central Philipstown to the northern town boundary abutting Dutchess County.

A graphic sense of the Town's topography is evident on a black-to-white hillshade maps (Figure 1). The valleys and ridges create many isolated sub-basins, within which groundwater is locally recharged and flows from upland areas toward receiving streams or the Hudson River. Some of these sub-basins are delineated on Plate 1. There is little to no opportunity for groundwater in adjacent sub-basins to interact or mingle within otherwise common aquifers due to topographic features which define and isolate the separate basins.

2.3 Geology

Geologic formations in Philipstown include both the underlying bedrock formations supporting the essential regional landforms and the overlying sediment formations often consisting either of thin soils in upland areas or thicker sediments in valleys.

Philipstown lies in the Hudson Highlands region, where bedrock consists generally of granitic rock types or high-grade metamorphic (altered) gneisses (from granites) and metasediments (from sedimentary rocks) (Figure 2). From north to south, the more dominant bedrock formations in Philipstown include

- <u>Hornblende-rich granitic gneiss</u> under Breakneck Ridge and Bull Hill. This formation is a metamorphically-modified granite, highly resistant to weathering and erosional processes. Inspection of Figures 1 and 2 indicates that this weathering-resistant formation underlies some of the steepest slopes and highest points in the Town.

- <u>Pyroxene-rich gneiss</u>, <u>garnet-rich gneiss</u>, and <u>biotite-quartz-plagioclase-paragneiss</u> underlie the valley between Breakneck Ridge and Bull Hill, the valley descending to Nelsonville and Cold Spring, and the moderately rolling lands extending under parts of the Clove Creek valley and northeastward past the Beacon Reservoir to the northeast corner of Philipstown. The modest relief supported by this formation (c.f. Figure 1) suggests these bedrock geologic formations are all robust (e.g either more fractured or prone to weathering) than the hornblende-rich granitic gneiss underlying Breakneck Ridge and Bull Hill.

- <u>Garnet-bearing paragneiss with some interlayered quartzite</u> underlies most of south-central and eastern Philipstown, extending from the northeast corner of Philipstown to the Westchester County boundary. This formation supports Round Hill, Sugarloaf Hill and Canada Hill. Like the formational grouping in the bullet above, this formation also supports modest rolling uplands but not the highest elevations in the Town.

- Mixed formations including some marble. The southeast corner of Philipstown near Continental Village includes several closely-associated bedrock formations, including elongate strips of amphibolite, biotite-granite gneiss, diorite, and calcitic/dolomitic marble. These formations are primarily metamorphic equivalents of sedimentary formations and, on the basis of their moderate elevation and heavily-dissected valley network, are perhaps among the least competent formations (e.g. most highly fractured and weathered) formations in the Town.

Although landform analysis clearly suggests some differences in the competence of different bedrock geologic formations in Philipstown, these bedrock formations all support elevations far higher than those found in adjacent Dutchess or Westchester counties, attesting to their relatively massive nature with less weathering and perhaps fracture frequency than bedrock in lower-elevation adjacent counties.

Geologic well logs available in the Putnam County Department of Health offices indicate that few wells intersect more than one formation. This means that the boundaries between the various bedrock formations in Philipstown are somewhat vertical in nature, rather than being organized as horizontally stacked layers. Many contacts between the bedrock formations are also simple rock-on-rock transitions, and so may not exist as fractured zones containing useful quantities of groundwater.

Figure 3 identifies prominent linear features which may identify underlying linear fracture systems in the Town, cross-cutting boundaries of the bedrock formations described above. Inspection of Figure 3 shows these features mostly do not follow bedrock formation boundaries, and therefore more likely reflect fractures or faults resulting from tectonic pressures (Isachsen, et al. 1991). Repeating parallel linear features extend from east-to-west and from north-to-south. Some of these were noted by Groff, Anders & Jaehnig (1985). For hydrogeologic purposes, any extensive fractures responsible for these linear features would be potentially beneficial as structures to store or transmit groundwater. Areas with intersecting fractures could be represent particularly fruitful areas for installing higher-yielding wells able to collect water from groundwater recharge areas extending outward along elongate fracture-trace areas.

Where fractures are absent, the bedrock formations in Philipstown have no inherent porosity, meaning that.water is only stored or transmitted through fractures, not in pore spaces. This condition means that joints and fractures are critical factors in the productivity of particular aquifer areas.

A limited number of faults in the Town trend approximately from the southwest to the northeast. The water-bearing capacity of these is variable since some may be filled with fault gouge resulting from rock-on-rock movement. Grossman (1957) and Miller (1989) note these traces. These can be easily confused with alignment of ridges or the boundaries between bedrock formations and so should be investigated as potential water-bearing groundwater zones with care. Such alignments identified by prior investigators parallel Breakneck Brook, Foundry Brook, and the Conopus Creek. These intersect the linear features described above and shown on Figure 3 at oblique angles.

Most fractures in Philipstown dip steeply into the ground, rather than extending laterally at low angles. Some nearly horizontal jointing with parallel the land surface has been noted in Garrison (Grossman, 1957) resulting from the delamination of rock layers as formerly deeply-buried rocks de-pressurize as weathering brings them closer to grade.

Detailed mapping of fractures and geologic features throughout Putnam County was completed by Groff, Anders & Jaehnig (1985). Prucha (1968) noted that bedrock is more extensively fractured in western portions of Putnam County - a factor perhaps contributing to the generally more rugged terrain in Philipstown and Putnam Valley than that found elsewhere in Putnam County.

Sedimentary deposits overlie bedrock formations throughout Philipstown, ranging from thin clayey soils on hillside areas to deep sediment deposits in some valleys. These sediments were all deposited under and near glacial ice covering Philipstown as recently as approximately 20,000 years ago.

The usually clay-rich deposits of glacial till found on hillsides and hilltops were deposited under or on top of glacial ice. Glacial till usually contains a wide range of sediment sizes and can contain boulders. Many till deposits contain significant clay although some more granular till deposits can occur. These sediments were transported along with the ice, and then either compressed under the ice or left behind as the ice melted as a loose, unsorted mantle draped over upland areas. During rainfalls, runoff rates can be high off such soils where only limited water can infiltrate downward through the soil. Domestic wells drilled in areas covered by glacial till are normally extended downward through the till into underlying bedrock, capturing water in bedrock fractures. The rate of water replenishment into such rock aquifers is controlled by the rate that precipitation can infiltrate through the till to recharge the rock fractures.

Sediments in valleys are often looser and better sorted than hillside glacial till depsoits. A wide range of water-sorted deposits, including sand and gravel, layered silt, and clay are found in valleys (Irwin, 1987; Grossman, 1957). Sand and gravel deposits are the result of flows of melting glacial water, depositing sediments by size and weight classes depending on velocity of the stream flow. Where sediments were deposited immediately adjacent to glacial ice, in valleys or on hillsides, sediment size variation may be particularly great. Such highly-variable water-sorted deposits are referred to as glacial kame deposits by geologists

Where sand and gravel today lie below the watertable, the clean and open pore structure can allow installation of high-capacity wells. Such deposits of sand and gravel in Philipstown are restricted primarily to the Clove Creek valley in northern Philipstown, although some limited deposits may lie in other, smaller valleys. Only a few wells installed in these sediments are recognized in Putnam County's well log database. These are shown on Figures 4A and 4B and correlate closely with areas where these soil and surficial geology maps identify the presence of outwash (mostly sand and gravel) deposits.

Various investigators and programs have mapped surficial deposits in Philipstown. Figure 4A shows a map prepared by TCC from Putnam County's soil survey maps. To prepare this map, TCC linked the geologic formation listed for each soil to the County's soil map. The analysis suggests that most soils in Philipstown have developed on glacial till deposits, with only small areas where soils are derived from glacial kame and outwash sand and gravel. These more granular soils lie in linear valleys in the northern half of the Town. Figure 4B shows the surficial geology map prepared by the New York State Museum and the New York Geological Survey (Cadwell, 1989). The level of detail available for this mapping effort was more global than that of the soil survey, resulting in less detailed mapping boundaries and a broader estimate of the extent of outwash deposits along Route 9 in northern Philipstown.

The state geologic map identified glacial kame deposits along the Hudson River south of Cold Spring, which, if present, could provide good locations for potential high-capacity sand and gravel water supply wells; however, soils maps and cursory confirmatory soil inspections made by The Chazen Companies, and the steep topographic drop in this area down to the level of the Hudson River, suggest that only limited, usable, saturated sediments are likely to be available in this area.

The NYS geologic map also identifies the potential presence of outwash and kame deposits along the Canopus Creek near and upstream of Continental Village, which the soil survey does not confirm. A cursory Chazen site visit to this area notes the presence of some level land along the valley floor of the Canopus Creek but the infrequent bedrock outcrop areas and generally settled nature of most of these areas reduces their likely suitability or availability for well development in this area. In general, The Chazen Companies judges the Figure 4A map based on soil delineations to be a closer estimate of the geologic nature of surficial soils in Philipstown than the Figure 4B Surficial Geology map.

Soils now developed in the uppermost horizons of these surficial geology deposits significantly reflect the composition of the parent glacial deposit and also significantly influence rates of groundwater recharge to underlying surficial and/or bedrock aquifers.

2.4 Land Uses

Forested lands and lightly-settled lands and wetlands are dominant land uses in Philipstown, followed by residential and limited commercial land uses. Concentrated residential development exists around Cortlandt Lake and in the Villages of Nelsonville and Cold Spring. Mixed use residential and commercial areas extend along a north-south valley in the northern third of Philipstown, containing also NYS Route 9 and the Clove Creek. In general, the town's commercial, manufacturing, industrial, warehousing, and golf land uses are clustered along transportation corridors or near the larger waterbodies.

Only Cold Spring has a collective sewer system to collect regional wastewater. Collective water districts exist in Cold Spring and in parts of the Continental Village area near Cortlandt Lake.

Typical groundwater quality impacts associated with various land uses include the following:

- Residential Development. Where septic systems are situated close to one another, groundwater quality may be over-loaded with discharges of nitrate, personal-use chemical discharges such as caffeine, pharmaceutical or hormone treatment residues, bacteria, and viruses. Wells or surfacewater bodies near such areas may be negatively affected as groundwater flows into these waters unless adequate recharge or open water movement is available to process or dilute these discharges. Groundwater quality in residential areas can also be impacted by homeowner releases of household chemicals and/or over-application of lawn fertilizers or pest control chemicals.

- Commercial and Industrial Uses. Groundwater quality can be affected by releases of petroleum, solvents, pesticides/herbicides, and dissolved metals. Risks of groundwater contamination associated with road deicing chemicals (salt) tend to be higher in commercial centers because de-icing efforts are often more intensive and paved coverage tends to increase.

- Agricultural. Few groundwater quality threats from agricultural activities are suspected in Philipstown, in part because of the scarcity of such activity in the Town.

Discrete areas of groundwater contamination (e.g. spill sites) are assumed to exist in Philipstown, Nelsonville and Cold Spring but were not the focus of this investigation. Further discussion of groundwater contamination which can be associated with these various land uses are summarized in Section 3 of this report. Limited new groundwater sampling data are found in Appendix A and discussed in Section 3.5.

Traditional sewage collection and treatment systems play varying roles in groundwater quality relationships. Where sewer pipe leaks are minimized, districts beneficially collect and treat many wastewater contaminants rather than allowing them to be released in a less intensively treated manner to aquifers via septic systems. Where sewer districts, exist, there is less water evaporative loss since transpiration and evaporative losses over septic system leaching fields are avoided. Swer districts also guarantee a daily minimum flow into streams or open waterbodies since, regardless of season, the wastewater plant will discharge water collected from its user district area.

Sewer districts, however, reduce local replenishment of aquifers since all water is exported at least some distance to a treatment plant rather than having wastewater returned on individual parcels. This can reduce local availability of groundwater to aquifer and wells within or near sewer districts, and can result in local streamflow depletion if groundwater previously flowing to streams is intercepted and used at homes, and released downstream at a sewage treatment plan. Such conditions occur routinely in Rockland County where regional water supplies and sewer district result in intensive water collection at a discrete network of wells, and distant downstream returns of treated wastewater. The potential for such impacts to occur in Philipstown should be assessed during the design process of any geographically significant sewer district. Modern sewage treatment plants are also not designed to treat all emerging classes of contaminants, such as pharmaceutical residues or caffeine.

Additional discussion of sewage treatment options which could be considered for use in Philipstown are summarized in Appendix B.

2.5 Water Requirements, Consumption, and Wastewater Generation

Residents on individual wells generally use between 80 to 100 gallons per day (gpd). Residents receiving water from central water supplies, who pay directly for their water, are generally more conservative in their water use and require only between 60 and 80 gpd. Water uses in Philipstown are expected to peak in summer due to outdoor water uses, increased presence of seasonal residents, and activity at camps.

Using conservative water use estimates, approximately 5,200 Philipstown residents living outside of Cold Spring and outside of those portions of Continental Village and Nelsonville served by central water supplies use groundwater, withdrawing a maximum of potentially 500,000 gallons per day (mgd). The balance of Philipstown's approximately 9,400 residents receive water from surface water sources.

Of the total gallons of groundwater withdrawn in Philipstown, each resident is estimated to "consume" approximately 20 gallons of water daily, therefore generating between 60 to 80 gallons of wastewater. The "consumed" fraction refers to water evaporated or transpired to the atmosphere rather than returned as wastewater. Water is consumed by perspiration, steam from cooking, and evaporation from watering of plants, washing of cars, and during drying by dishwashers and clothes driers.

During winter, virtually 100 percent wastewater released to septic systems returns to aquifers except in rare instances where septic wastes travel laterally along clay layers directly to nearby water bodies. Wintertime residential uses of groundwater therefore result in 400,000 gpd of wastewater discharged to septic systems and hence to aquifers. During summer, 30 to 50 percent of wastewater passing to septic leaching fields may be drawn upward by evaporation or root transpiration (Chazen, 1999; LBG, 2001). Summertime septic system evaporation and transpiration losses in Philipstown from those using groundwater are estimated at approximately 120,000 gpd, so that only 275,000 gpd of wastewater released to septic systems replenishes Philipstown's aquifers during the warmest months of the year.

Prior investigations have estimated that non-residential uses of water in most communities add 50 percent more usage to the residential uses (Goodkind & Odea, 1970). Using this approximate value, total groundwater use and consumption estimates for residential and commercial/business/organizational sectors in those parts of Philipstown reliant on groundwater resources are estimated below:

- Total Groundwater withdrawn from aquifers: 750,000 gallons daily
- Winter water returns to aquifers from septic systems: 600,000 gallons daily
- Summer water returns to aquifers from septic systems: 400,000 gallons daily

2.6 Climate, Vegetation and Imprevious Surfaces

Precipitation data indicate that the mean annual precipitation in Philipstown is between approximately 46 and 48 inches per year (Figure 5), increasing to the south. A majority of aquifer recharge typically occurs in the autumn and in the spring when the ground is not frozen in winter or lost to evapotranspiration processes in summer.

Typical evaporation and plan transpiration rates in Philipstown are estimated to remove between 20 and 21 inches (Randall, 1996), leaving approximately 24 inches per year available to recharge aquifers and to flow as runoff into streams and reservoirs.

Future climate patterns in the region are not fully understood, however, many investigators believe future weather may include more severe storms and longer rainless periods between storms with overall warmer temperatures. Such projections would likely affect aquifer recharge rates by increasing evaporative losses during periods of increased temperatures, and increasing runoff fractions since runoff is greatest during heavy storms. Combining these two influences may result in reduced total aquifer recharge. If recharge rates are reduced and the intervals between recharge events become greater, heavier future reliance will be placed on the long-term groundwater storage capacity of aquifers between recharge events.

Soil Conservation Service programs, such as TR-55 document how runoff changes as land uses change. In general, increases in runoff result in decreases in aquifer recharge. Analysis completed by Chazen (2006b) in the Wappinger Creek watershed in Dutchess County concluded that runoff changes related to vegetation or impervious cover changes are most pronounced during the heaviest of rain events, while changing runoff very little during typical, modest rainfalls. Only where connected impervious surfaces exceed approximately 30 percent do runoff values increase markedly under the more common, low-volume rainfalls. Discontinuous impervious surfaces (e.g. roof drains flowing onto lawns) rather than continuous impervious surfaces (road gutter systems directed to a common surfacewater discharge) minimize recharge losses associated with impervious surfaces.

3.0 PHILIPSTOWN GROUNDWATER RESOURCES

Aquifers provide water to over half of Philipstown's residents and for most of its commercial activity outside of Cold Spring. Due to the limited number of water-bearing sand and gravel aquifers, most groundwater in the town is withdrawn from bedrock aquifers.

Aquifers are geologic formations that provide useful amounts of groundwater. For domestic well purposes, the Putnam County Department of Health can approve the use of wells yielding as few as two gallons per minute (gpm). Since all geologic formations in Philipstown normally support at least such yields, this report considers all geologic formations in the Town and the two Villages to be aquifers.

Precipitation recharges aquifers where water infiltrates through soils to the underlying geologic formations. Recharge occurs on all geologic formations in Philipstown. Once precipitation reaches the watertable, usually approximately 20 to 30 feet below grade except near streams where it is closer to grade, this water then migrates within the aquifer through pore spaces or fractures toward lower elevations, finally re-emerging in hillside springs or as stream baseflow.

In general, groundwater flow through the subsurface mimics the same topographic basins as surface water watersheds. Figure 1 provides a graphic portrayal of topography in the municipality. Plate 1 shows estimated groundwater flow directions.

3.1 Bedrock Aquifers

Bedrock aquifers, consisting of solid rock with fractures conveying groundwater, underlie all of Philipstown, Cold Spring and Nelsonville. Bedrock formations have lower average well yields than sand and gravel aquifer formations because of lower overall porosity and interconnectedness in the fractures and joints found in bedrock formations.

Well log data were previously assessed to quantify well yields throughout Putnam County (Chazen, 2004). Yield data for each bedrock formation in Philipstown are provided on Table 1. Plate 1 shows the locations of digitized domestic well logs for wells installed prior to approximately 2003.

Although occasional wells can miss all water-bearing fractures, most wells advanced to at least approximately 300-feet deep throughout Philipstown yield at least between 7 and 10 gallons per minute (Table 1). Jaehnig (1988) indicates that not more than approximately 10 percent of bedrock wells in Philipstown provide yields over 30 gpm.

Grossman (1957) and Chazen (2004) report that well yields in most Putnam County bedrock formations increase where installed at lower elevations. This may be because lower elevation areas coincide with areas with higher fracture densities able to store and transmit groundwater. The reliability of yields in lower elevation wells is also to be expected since groundwater recharged in higher elevations areas migrates toward and supports yields in lower elevation areas. Chazen (2004) identified in particular that wells over 400 feet yield deep in lower elevation areas showed significantly higher yields than wells of equivalent depth at higher elevation.

Well driller yield estimates used in the yield statistics shown on Table 1 are mostly derived from short-duration flow tests conducted by well drillers shortly after completion of each well. This is an acceptable data limitation given that most domestic wells are used intermittently, as is typical for domestic water demand purposes. Longer-term testing of each would be necessary to identify the continuous sustainable yield of wells in Philipstown's bedrock aquifers, and results would be as contingent on recharge available through cover soils as on the fracture connections within the bedrock formations.

Table 2 documents a current general trend toward drilling deeper wells in Putnam County. Many wells are today advanced to more than 400 feet of depth while older wells were commonly terminated at less than 200 feet. Likely reasons for this shift are not attributed to groundwater depletion since streams reliant on groundwater discharges continue to flow in Philipstown and regional water table elevations are not falling; instead, the trend to deeper wells reflects homeowner desires for higher yields, and a shift to use of air rotary well drilling methods which are more economical than older drilling methods but sometimes leave drilling fines in smaller fractures, so that drilling must be advanced further to meet yield goals.

3.2 Surficial Aquifers

Where valleys in Philipstown contain saturated glacial outwash or kame sand and gravel deposits, they can transmit and yield significant quantities of groundwater. Grossman (1957) indicated that the average well yield from such surficial aquifers in Putnam County was 33 gpm, ranging from 1 to 450 gpm. Few domestic wells are known to be installed in surficial formations in Philipstown (Figure 4A/B), but because porespace up to 30 percent allows considerable water storage, groundwater draining from such aquifers can support stream flows during extended dry periods or can replenish wells installed in underlying bedrock aquifers.

Few sand and gravel deposits are found in Philipstown. Tim Miller Associates (TMA, 1991) used well records to dimension the approximate extent and likely well yields available from sediment aquifers in Philipstown (Figure 6A). A NY State regional map identifies similar potential yield areas (Figure 6B). Comparing the surficial aquifer areas identified on Figures 6A and 6B with outwash or kame sands and gravel recognized by soil survey maps (Figure 4A), suggests the extent of high-yielding surficial aquifers in Philipstown may be somewhat more limited than the areas shown on Figures 6A and 6B.

Valley-fill aquifers often serve as conduits for groundwater movement out of upland bedrock aquifers toward valley streams. Groundwater recharged in upland bedrock aquifers migrates downward, through and out of fractures, into valleys sediments. From these sediments, groundwater then moves toward the streams. This relationship between upland groundwater and valley groundwater can enhance the reliability and yield of wells installed in valley sediment formations.

3.3 Soils and Aquifer Recharge

Soils substantially control rates of surface water entry, or recharge, into underlying aquifers. Soil mapping conducted by the Soil Conservation Service assigns Hydrologic Soil Group (HSG) rankings to every undisturbed soil. Recent investigations by Brandes et al (2005) demonstrate that the distribution of Hydrogeologic Soil Groups in a watershed correlates closely with recharge to underlying aquifers. The distribution of Hydrologic Soil Groups in Philipstown is shown on Figure 5.

Hydrologic Soil Group A and A/D soils allow high infiltration rates and consist chiefly of deep, well- to excessively-drained sand or gravel. There are few HSG A soils in Philipstown. Even in the Clove Creek valley where there has been a history of sand and gravel mining, most soils contain sufficient fine sand or silt that few are assigned to HSG A.

Hydrologic Soil Group B soils have more moderate infiltration rates than HSG A soils, and consist chiefly of soils with moderately-fine to moderately-coarse textures. HSG B soils are commonly found in lower elevation areas in Philipstown, including under much of Nelsonville and Cold Spring, the Route 9 and 9D corridors, and the general area surrounding Continental Village.

Hydrologic Soil Group C and C/D soils have low infiltration rates and consist chiefly of soils with sufficient silt to substantially impede aquifer recharge. These soils have moderately-fine to fine textures and are found in areas with soils derived from glacial till. Many higher elevation areas in Philipstown are mantled with HSG C soils.

Hydrologic Soil Group D soils have the lowest infiltration rates of any natural soils, and consist primarily of clay. Except for limited pockets in a few valley settings, there are few HSG D soils in Philipstown with the exception of clayey soils near Constitution Marsh.

Figure 5 indicates that soils in Philipstown are almost evenly divided between Hydrologic Soil Group B and C or C/D soils, together comprising nearly 95 percent of total land area of the Town and two villages. Cold Spring and Nelsonville are primarily underlain by disturbed soils not given an HSG assignment, but pre-existing soils are likely to have been a combination of HSG B and C soils. In general, HSB B soils follow valleys and HSG C soils are found on steep hillsides and uplands.

A recent study in Dutchess County calibrated estimated aquifer recharge rates using Hydrologic Soil Groups (Chazen, 2006a). Aquifer recharge rates in the Fishkill/Sprout Creek watershed nearest to Philipstown were estimated at 19.2 inches/year through HSG A and A/D soils, 14.0 inches/year through HSG B soils, 7.2 inches/year through HSG C and C/D soils, and 4.0 inches/year through HSG D soils. Mean annual precipitation between 1951 and 1980 in the Fishkill/Sprout Creek watershed was 42 inches per year, while mean annual precipitation in Philipstown was approximately 15 percent greater, ranging between 46 to over 48 inches (Randall,1996). The 46 and 48 rainfall isopleths are shown on Figure 5.

Aquifer recharge rates in Philipstown are likely to be in the range of 10 percent higher than those in the Fishkill/Sprout Creek watershed since rainfall is approximately 15 percent greater in Philpstown, but runoff rates in Philipstown may be slightly higher due to steeper slopes. For planning purposes, the following estimates of aquifer recharge are likely to be generally correct.

- 20.2 inches/year through HSG A and A/D soils,
- 14.7 inches/year through HSG B soils,
- 7.6 inches/year through HSG C and C/D soils, and
- 4.2 inches/year through HSG D soils.

Calibration of more precise recharge rate estimates with stream baseflow data was beyond the scope of the current study, and may not be possible unless long-term stream-gauging records from streams in Philipstown are available. Although copious runoff can be observed flowing off hillsides and uplands in Philipstown following heavy rain events, the general similarity in bedrock well yields reported by well drillers in both Putnam and Dutchess Counties suggests precipitation does nevertheless successfully enter bedrock fractures in Philipstown.

Using the above aquifer recharge values, and assigning an estimated mid-range recharge rate value of 10 inches per year to unranked areas with disturbed soils, total estimated aquifer recharge entering aquifers throughout Philipstown, Cold Spring and Nelsonville averages 26 million gallons per day, with most recharge occurring at rates of 1,094 gpd per acre through HSG B soils and 565 gpd per acre through HSG C soils. During drought years, average daily rates may decline by as much as 30 percent.

A daily average aquifer recharge rate of 26 million gallons falls within a range of values developed by prior investigators. Chazen (2004) applied and summarized methods by others, identifying estimating daily average aquifer recharges of 32 million gallons (Maslansky & Rich, 1984), 23 million gallons daily (Wolcott & Snow, 1995) and 17 million daily gallons (Gerber, 1982). Chazen previously estimated that Philipstown might received 20 daily million gallons (Chazen, 2004) on the basis of the older studies. On the basis of the aquifer recharge calibration work completed in Dutchess County, we believe our current value of 26 million gallons per day is likely to be a closer estimate.

Sustainable use of daily average aquifer recharge may be defined on the basis of reliable well yield and quality, and on the preservation of aquifer baseflow to support streams and other surface water resources. During the dry summer of 2002, the Putnam County Department of Health received many well re-drill requests. Nevertheless, The Chazen Companies are not aware of evidence indicating that regional aquifer systems are overtapped in Philipstown or elsewhere in Putnam County. Instead, the 2002 demand for well replacements is interpreted as a period of aquifer stress when various marginal wells required deepening or replacement.

Groundwater may be locally over-used, but the recharge rates estimate of 26 million gallons of water recharge Philipstown aquifers each day significantly exceeds Section 2.6 water extraction estimates of 750,000 gpd. Water not pumped by wells, and aquifer replenishment from septic systerm return flows, leaves a vast majority of regional groundwater recharge available to preserve regional stream flows and water table conditions.

Groundwater flows supporting streams and riparian wetlands come both from the aquifer recharge flows described above, and from more transient groundwater movement known as interflow, following root channels, clay seams, or buried bedrock surfaces without penetrating deeply enough to reach the perennially water-bearing aquifer formations. Interflow contributions to streams likely adds 35 percent more baseflow to streams in Philipstown than that coming from aquifer recharge alone (Chazen, 2006b). Such "interflow" represents an important portion of stream flow for a week or two following rainfall events; as this contribution eventually drains completely, baseflow from the underlying surficial and bedrock aquifers is relied upon to maintain continuing stream flow through longer droughts.

3.4 Groundwater Flow

Plate 1 shows the estimated elevation of the watertable, or upper groundwater surface, of aquifers throughout Philipstown. The estimates are based on evidence from observed perennial streams, ponds, and available well log records. In general, groundwater fills pore spaces and factures within 20 to 30 feet below groundlevel in most areas, and nears the ground surface in the vicinity of streams, ponds, and streamside (reparian) wetlands.

Groundwater moves toward lower elevations in the same manner as surfacewater, albeit far more slowly due to the intricacies of the pore and fracture pathways. Thus, groundwater flow is always from points of higher elevation to points of lower elevation, where it then discharges to valley stream systems. Flow arrows shown on Plate 1 show these estimated general directions of groundwater flow, which can be used for general flow analysis.

This map may be used to estimate recharge areas for particular wells by inspecting lands upgradient (up-arrow) from areas of interest. It may also be used to identify areas downgradient (down-arrow) from any land uses of concern. Plate 1 also shows some of many discrete subwatersheds within Philipstown. Although bedrock aquifers are continuous across the Town and Villages, groundwater recharged in one subwatershed cannot move through the subsurface to other subwatersheds. Plate 1 makes evident the importance of considering the sustainability of groundwater uses in each subwatershed and discrete area of use.

3.5 Groundwater Quality

Groundwater quality throughout Philipstown is generally potable and should be considered and managed as a reliable source of good quality water. As a result of contact with some geologic formations, and due to some human activities, groundwater quality can sometimes fail to meet some potable water standards, warranting either aquifer remediation or point-of-use treatment norma.

Reviews of natural and human-caused groundwater quality defects follow. Groundwater generally remains the most economical and accessible source of potable water throughout most of Philipstown.

A limited groundwater sampling program was initiated as a part of the current groundwater study, as discussed below.

3.5.1 Natural Groundwater Quality

Natural concentrations of dissolved iron, manganese, elevated radiologicals (e.g. radon) and occasional hardness are mentioned as common natural water quality defects in Philipstown's bedrock aquifers. Iron and manganese are largely aesthetic concerns. Hardness can lead to calcification of water pipes but is not considered a health hazard. Grossman (1957) summarizes general groundwater quality trends associated with the County's various geologic formations. Differences in total dissolved solids reflect tendencies of various formations to influence groundwater quality. Groundwater in carbonate formations is, for example, generally higher in dissolved solids than other rocks. Deeper wells also tend to have higher degrees of mineralization largely because the greater residence time of groundwater cycling through deeper fractures.

General groundwater mineralization trends summarized by Grossman (1957) are shown on Table 3. Groundwater in carbonate formations such as the dolomitic marble near Lake Cortlandt and the Stockbridge limestone tends to have higher sulfate, hardness, and total dissolved solids than other formations. Iron and sulfate are highest in groundwater from granitic, gneiss and schist formations. Unconsolidated deposits may exhibit elevated total dissolved solids and hardness but have few other native defects; such formations may, however, be more susceptible to land use contaminants due to their proximity to grade. Studies have noted that manganese often accompanies elevated iron (Miller, 1991). In some cases, mineral deposition in wells can lead to decreased yields over time which do not signal aquifer depletion, but rather indicate that the well may need to be rehabilitated or redrilled.

Radon is more often present in buildings as a result of gas migration from deeper bedrock formations, but may also enter homes off-gassed from groundwater. Radon 222 is a natural daughter product of Radium-226, which is a native constituent in some of the Hudson Highlands gneisses. Deep fractures provide pathways for radon contact with groundwater resources (Miller, 1991). Putnam County wells sampled during 1989 and 1990 recorded the highest average radon concentrations in New York State (NYSDOH, 1990), with an average concentration of nearly 4,000 picoCuries per liter of water.

Three groundwater samples were collected by Town volunteers as part of this study, with results ranging from 380 to 2,100 picoCuries per liter (pCi/L) (Figure 8 and Appendix A). There is no current drinking water standard for radon, but no sample exceeded a contemplated future EPA Alternative Maximum Contaminant Level of 4,000 pCi/L and all three exceed a more conservative contemplated Maximum Contaminant Level of 300 pCi/L. The distribution of elevated radon-containing groundwater in Philipstown is variable, may be associated with particular geologic formations or with particularly deep fracture systems, but is otherwise not well understood. Treatment methods are available but difficult to manage.

In addition to the natural compounds of concern above, mineral deposits and former mines can locally influence groundwater quality. The approximate location of some historic ore mines are shown on Figure 2. In 1988, the Putnam County Department of Health collected groundwater samples from domestic and other wells near some formerly active mining locations. They found few instances of drinking water standards exceedences. Groundwater samples show considerable variability, with some samples exceeding standards for iron, manganese or copper, other samples exhibiting no apparent problems, and still others showing elevated of aluminum, iron or lead although below standards (Bittner, 1989). The variability in these analyses may in part be explained by sampling limitations where wells accessible to the Department of Health were not always situated downgradient of the mines. Since 1988, new homes may be been constructed near ore bodies and former mines, and some drinking water standards have been revised, so re-examination of public health exposure to such dissolved mineral concentrations may be warranted.

Arsenic-containing minerals occur in several locations in Putnam County. The N.Y. State Museum has one arsenopyrite sample from Philipstown, reportedly from the Anthony's Nose area, associated with copper and iron minerals.

The only confirmed radioactive minerals in Philipstown come from the "Phillips Mine" region in the extreme southwest corner of the town. The Phillips Mine reportedly lies near the intersection of Lehman Road and Iron Mountain Road. The mine site may include three shafts reportedly within 100 feet of the Westchester County line and two adit entrances near Lehman Road. According to U.S. Geological Survey Bulletin 1074-E (Klemic et al., 1959), the ore body is composed mainly of iron sulfide and copper-iron sulfide minerals such as pyrrhotite, pyrite and chalcopyrite. The source of uranium is the mineral uraninite.

A former copper mine reported also lies near Anthony's Nose in Philipstown, and numerous former iron mines occur in Putnam County including some in Philipstown.

Ore deposits summarized here were identified by Chazen (2004) from reports at the Putnam County Historian's office or the NYS Museum in Albany. Where coordinates were available, mine locations are shown on Figure 2. Sand and gravel mines or aggregate rock quarries have little history of being sources of groundwater contamination so are not shown on Figure 2.

3.5.2 Introduced Contaminants

Virtually all year-round roads in Philipstown represent sources of potential salt contamination to groundwater quality. A recent USGS study (Heisig, 2000) estimated that two-lane roads in Putnam and Westchester counties are salted at average rates of 37 tons per mile of road per year. The USGS study documented that chloride concentrations in streams were highest in watersheds with the most roads, closely relating road mileage to salt concentrations in the streams. Chloride concentrations in the streams sampled by USGS ranged from approximately 5 to nearly 200 mg/l (parts per million). The samples were collected in summer when water in the streams normally comes from the local aquifers rather than from overland flow.

Road salt contamination tends to most severely impact aquifers where flat topography, and inadequate curbing or other road runoff management allows excessive infiltration of salty snowmelt into the ground. Salt contamination of aquifer also can occur at ends of cul-de-sacs where melting and salty snow piles may accumulate, or near any uncovered salt-storage piles.

Homeowner complaints of road salt contamination are reportedly received by the Putnam County Department of Health during most winters (Bittner, personal communication). Where such seasonal variation is noted in salt complaints, road salting rather than water softeners is the suspected source of salt since road salting is heaviest during winter and spring months. Rates of road salting have generally increased in all northeastern States over the past three decades as public expectations for winter road drivability have evolved. No regional well sampling program has documented the full extent of road salt impact on groundwater quality.

Water softeners release salt to aquifers when regeneration wastes are discharged to septic systems. Several of the watersheds studied by Heisig (2000) were fully sewered and yet contained salt in their streams. This suggests road salt, rather than water softening salts are the dominant source of sodium chloride in aquifer and streams (Heisig, personal communication). Nonetheless, where softeners are extensively used, Heisig indicates that use of up to 700 or even 1,000 pounds of salt per year (equal to as many as 25 forty pound bags per year) is not unusual. Heavy softener use is most likely in areas with hard water coming from carbonate aquifers or areas with elevated iron in bedrock aquifers. Elevated iron associated with many bedrock formations in Philipstown and the marble bedrock situated near Continental Village is a carbonate formation (Figure 2). Conversations with Putnam County Department of Health personnel confirm that water softener salt complaints are usually received from individual sites rather than over broad areas, while road salt complaints normally come from clusters of well owners (Bittner, PCDOH, personal communication). Sampling guidance developed by the NYS

Department of Transportation can be used to help distinguish between road salt and water softener salt contamination. The guidance document is available from the Putnam County Department of Health. Sodium concentrations in drinking water exceeding 20 mg/l are not recommended for those on severely restricted sodium diets, and water containing over 270 mg/l should not be used by people on moderately restricted sodium diets, according to NYS Department of Health regulations.

Individual septic systems are used throughout Philipstown and in the Village of Nelsonville. Using a generally-accepted estimate that 80 percent of water from homes and businesses becomes wastewater, wintertime discharges of domestic wastewater to aquifers from septic systems in Philipstown and Nelsonveille have been estimated at approximately 400,000 gallons daily (Chazen, 2004). In summer, wastewater discharges entering aquifers from septic systems are reduced by evaporative and plant use losses over septic system absorption fields, likely reducing domestic wastewater aquifer returns to approximately 275,000 gallons daily (Chazen 2004). Wastewater constituent concentrations in such summer returns are, however, likely to increase, resulting in somewhat constant seasonal wastewater constituent loading to aquifers.

Wastewater constituents include nitrogen compounds which typically convert to nitrate in aquifers. Nitrate does not decay much in aquifers and has a drinking water standard of 10 mg/l. The average person releases approximately 10 pounds of nitrogen waste per year (NJDEP, 2002). Where septic systems are too close together, groundwater quality can be locally degraded.

An older survey of water quality in Philipstown's few community water system wells identified no nitrate concentrations exceeding 2.1 mg/l (Miller, 1991); however, source water areas for community water system wells are seldom immediately surrounded by septic systems so these findings are reasonable and not predictive of groundwater quality in areas with concentrated septic system uses.

Sanitary wastewater contains phosphate as well as nitrogen wastes. The average person releases approximately 3 pounds of total phosphorous wastes each year (USEPA, 1980). Phosphorous in surfacewater can degrade lake or stream quality due to water over-nutrification. Phosphorous discharged by septic system bonds to soils, with a saturation front moving outward as soil bonding sites are sequentially exhausted, resulting in an advancing phosphorous plume downgradient from septic system which eventually reach aquifer discharge locations in streams, wetlands or lakes. Phosphorous is not regulated as a drinking water contaminant although phosphorous is a significant contaminant in surface water bodies.

A recent NYCDEP study (NYCDEP, 2000) demonstrated that phosphorous readily travels more than 100 feet from septic systems toward streams or other open waters. Studies elsewhere indicate that phosphorous plumes therefore advance approximately 3 feet per year (Dr. William Harman, University of Binghamton, personal communication). At such rates, new homes situated 300 feet from streams might expect phosphorous to reach the stream after approximately 10 years. The NYSDEP (2000) study conclusively documents a wide range of capabilities in different soil types to hold phosphorous, explaining why rates of plume migration will vary widely.

Bacteria and viruses are often assumed to die off or be sufficiently filtered within a few hundred feet of a point of release at a septic system. A NYCDEP septic system study, however, documented several cases where coliform migrated at least 100 feet from septic system leaching fields (NYCDEP, 2000). The NYS Department of Health requires stipulated separation distances between wells and septic systems to limit bacterial or viral transmission to wells. The Putnam County Department of Health does not routinely collect homeowner well samples for coliform analysis (Bittner, 2003, personal communication). Water quality samples collected in Dutchess County, however, show that *e*-coli coliform contamination in water samples collected during the driest months of 2002 rose to approximately 10% of submitted samples (TCC, 2003). *E*-coli coliform inhabits intenstinal tracts, so is a potential indicator of waste transmission between septic systems and wells. The increase in *e*-coli detections during dry periods suggests that wells may occasionally draw water from distant locations including from near septic system leaching fields during dry months. The Dutchess County data suggest that wells and streams in Philipstown may also be affected by coliform from septic systems, including some wells being at least seasonally affected by *e*-coli contamination.

Recent research indicates that a wide range of lifestyle chemicals are being released to wastewater systems (USGS, 2002) including septic systems. Chemicals include caffeine and medicines such as steroids, nonprescription drugs such as ibuprofen and acetaminophen, detergent byproducts and plasticizer chemicals from many flexible plastic containers. Few of these chemicals decay when released to septic systems; many have been found in watershed streams where septic systems are the only likely source of wastewater release (P. Phillips, USGS, 2003, personal communication). The relationship between septic system discharges and contaminant presence in streams suggests these chemicals migrate through aquifers from the septic systems to the streams and so may also be withdrawn from aquifers by wells.

No local studies confirming the presence of such life-style chemicals in groundwater are known to be occurring in the region. Sewage treatment plants are also not presently required to analyze or treat wastewater for these chemicals so few wastewater treatment data are available, and no drinking water standards yet exist for most of these chemicals although may be anticipated in coming years. Presently, dilution in stream flow or dilution in aquifers by other recharge appears to be the most readily available management approach for these chemicals.

Groundwater samples were collected by Town volunteers as part of this study from four properties in Philipstown (Figure 8 and Appendix A). Three locations lay along NYS Route 9 and one location was on Lane Gate Road. All four were analyzed for a basic suite of common VOCs (volatile organic compounds) and none were found to be contaminated by dissolved solvents or any petroleum compounds including MTBE. One did contain low levels of bromodichloromethane and chloroform in concentrations near drinking water standards; these compounds are typical byproducts of water disinfection from chlorination activities. Another well also contained a trace of chloroform. The sources of chlorine byproducts were not investigated by The Chazen Companies.

The three wells along Route 9 were also analyzed for nitrate and for dissolved concentrations of sodium and chloride. Nitrate concentrations ranged between 1.0 and 1.78 mg/L, all of which were below the drinking water standard of 10 mg/L. Septic systems are in use in all properties along NYS Route 9 but average parcel sizes and septic system locations in the sampling locations were not investigated by The Chazen Companies. Sodium concentrations in the three wells along NYS Route 9 were 4.18 mg/L, 37.6 mg/L and 368 mg/L with associated chloride concentrations of 52.4 mg/L, 70.5 mg/L and 399 mg/L. The New York State Department of Health has sodium advisory guidelines of 20 mg/L for those on severely restricted sodium diets and 270 mg/L for those on moderately restricted sodium diets, and a chloride standard of 250 mg/L. The sample results indicate that one location has water without sodium concerns, one has sodium slightly over the lowest guidance value and one has significantly elevated sodium as well as chloride exceeding drinking water standards. The source(s) of the sodium chloride in these wells was not investigated by The Chazen Companies.

Vulnerability of Philipstown aquifers to any of the sources of contamination described above is related to land uses and soil cover and aquifer relationships which may reduce contaminant infiltration rates in some cases. In general, most chemical spills occur in or near commercial or industrial areas. Most known instances of bacteria or nitrate well contamination occur in areas with heavy concentrations of septic systems. Most contamination of wells by road salt happens when wells are situated near roads at ends of cul-de-sacs or near low points along roads.

Aquifer vulnerability can also vary depending on permeability of soils, distance of the spill to a discharging location, and resistance of the formation to spill remediation. Where dense glacial till exists, rates of contaminant penetration into aquifers can be reduced. If spills occur close to where groundwater discharges into streams or wetlands, these ecological resources are more significantly harmed, but less aquifer zones are contaminated.

3.6 Future Water Supplies

Domestic wells have been drilled in all bedrock geologic formations in Philipstown. Inspection of Table 1 indicates that yields exceeding minimum homeowner requirements are available from all formations. Only occasionally will a second or even third well drilling attempt be necessary if a particular location is unusually devoid of a normal fracture distribution.

For existing community water systems, replacement or supplemental higher-capacity water supply wells will necessarily be sought in areas close enough to the existing system to justify pipe installation and other transmission costs. This limitation will focus efforts on saturated sediment deposits or bedrock formations near project areas.

When considering a broader search for groundwater resources, evidence of large-scale sub-surface fracture features may be sought by reviewing aerial photographs followed up by careful follow-up site reconnaissance. A cursory linear feature analysis was prepared by TCC (Figure 3). Concentrating drilling exploration work along such linear feature, and particularly in areas of intersecting linear features, is likely to increase opportunities to encounter waterbearing fractures. (Note that regional or local fracture trace work, geophysical surveys and field work investment will only increase odds, rather than guarantee, the drilling of successful higher-yeild bedrock wells.)

Development of new wells in the Town's limited sand and gravel deposits shown on Figures 4A/B and 6A/B will usually begin with soil borings to characterize the extent, depth, and sediment grain sizes in a desired location. Sometimes stream gauging work can also be conducted to identify stream segments gaining significant water from local sand and gravel aquifer reserves. Unconsolidated deposits with potential to support sand and gravel wells may lie along the Canopus Creek upstream from Continental Village, in small pockets in other valleys throughout Philipstown, and near Clove Creek along the northern section of New York State Route 9. After advancing exploratory borings, decisions can be made regarding the suitability of the sediments and the proper dimensions of well screens to install. The well screen can then be ordered, installed at selected depths, and flushed (developed) to remove finer-grained sediments immediately surrounding the screen.

For higher-capacity wells, yield testing will follow installation to confirm well reliability and quality appropriate to the new use. Part of testing analysis can include analyzing aquifer recharge near the new well on the basis of local topography and Hydrologic Soil Groups. Such pumping tests and aquifer recharge area analysis will help evaluate to the reliability of a new higher-capacity well and its potential withdrawal of water from adjacent off-site parcels or nearby streams.

Subdivisions proposing use of individual wells rather than central wells may also warrant collective and extended yield tests wherever average parcels sizes are below recommended minimum parcel sizes discussed in Section 4.0 of this report.

4.0 GROUNDWATER RESOURCE MANAGEMENT

4.1 Groundwater Summary

Aquifers represent the sole source of water for approximately half the current population of Philipstown. Surface water supplies have been developed for existing population centers in Cold Spring and parts of Nelsonville and Continental Village.

Sand and gravel aquifers may provide groundwater for future central water supply wells. The most extensive sand and gravel areas lie in the valley occupied by the Clove Creek. Smaller sand and gravel deposits which may lie below the watertable and thus provide opportunities for groundwater well installations have been mapped by prior investigators in small valleys throughout the Town. Under these regionally limited surficial deposits is a generally continuous fractured bedrock aquifer, capable of supporting individual well yields, and potentially capable of supporting higher yields where wells can be installed to tap intersections of more significant fractures. Groundwater within the town-wide bedrock aquifer moves locally toward the town's many streams, supporting surface water resources during dry periods.

Groundwater in the Town and two Villages is recharged by local precipitation infiltrating through overlying soils. Most recharge occurs at annual average rates of approximately 14.7 inches per year (1,094 gpd/acre) through Hydrologic Soil Group B soils or 7.6 inches per year (565 gpd/acre) through Hydrologic Soil Group C soils, which together cover over 90 percent of the municipalities.

A significant characteristic of aquifers in Philipstown is the isolation and segmenting of groundwater into many small watersheds by the rugged ridges extending across the Town. As a result, groundwater in each basin cannot mix or replenish groundwater in other basins although the same fractured bedrock aquifer may underlie both areas. Town-wide average daily aquifer recharge throughout the Town is estimated to exceed current demand by a factor exceeding 30 to 1; however, local area of groundwater over-use may still exist, either because of pumping which exceeds local recharge rates, or because septic systems are installed so close together that local groundwater quality is degraded.

4.2 Minimum Parcel Sizes

Where individual wells and traditional septic systems are likely to be in long-term use, average parcel sizes should be large enough that on-site recharge can both sustain well use and provide adequate dilution for wastewater discharges. Nitrogen is a component of domestic wastewater which is not fully treated by a septic system and does not decompose quickly in aquifers, so it is important to ensure that enough recharge is available around each septic system to dilute the nitrogen below drinking water standards. Where recharge rates are low, larger areas are needed to ensure dilution around each septic system, and where recharge rates are higher, a more dense arrangement of septic systems can be sustained.

To help identify minimum average sustainable parcel sizes in areas with wells and septic systems, this study recommends using a variation of a nitrogen-based septic system density model developed in New Jersey to establish minimum average parcel sizes in Philipstown. The modified formula is shown below.

$$A = (4.4186HM / CqR) + Isc$$

Where

A = recommended minimum acres per system, in acres (e.g. parcel size)
H = persons per system
M = pounds of nitrate-nitrogen per person per year, in pounds
Cq = Nitrate-nitrogen target average groundwater concentration, in mg/L
R = Annual Recharge Rate, in inches
Isc = Impervious surface cover, in acres.

This formula offers flexibility for evaluating unique projects, but may also be used with default values for broad planning purposes. The recommended default values are:

H = 2.6 persons per household, representing regional typical occupancy levels

M = 10 pounds of nitrate-nitrogen (Chazen, 2006a).

Cq = 5 mg/l, equal to half the nitrate drinking water standard so that, as results varying around this goal, most outcomes will be below the target.

Isc = 0.1 acres, to address driveways, roofs and other impervious surfaces.

R = use annual average recharge rates addressed elsewhere in this report for each of the four Hydrologic Soils Groups.

Using the recommended formula, minimum average parcel sizes suggested in Philipstown for areas using individual wells and traditional septic systems are as follows:

For areas with Hydrologic Soil Group A:	1.2 acres per system
For areas with Hydrologic Soil Group B:	1.6 acres per system
For areas with Hydrologic Soil Group C:	3.0 acres per system
For areas with Hydrologic Soil Group D:	5.4 acres per system

Figure 7 shows areas in Philipstown where existing parcels underlain by each of the four Hydrologic Soil Groups are below the parcel sizes referenced above. Where single parcels or small groups of parcels are identified, it is unlikely that well water quality is suffering since adjoining larger parcels are likely to be providing compensatory aquifer recharge to preserve groundwater quality. However, within larger clusters of under-sized parcels, some decrease in groundwater quality may be expected and some water quality samples may identify nitrate concentrations nearing or even exceeding 10 mg/l.

Additional sources of nitrate entering aquifers do exist but are not included in this density model. This because, if properly applied, lawn fertilizers are fully utilized by site vegetation and need not contribute to elevated regional groundwater nitrate concentrations. Moreover, lawn fertilizer is not used at all homes, and is applied at ground surface rather than being released below ground level as are septic system discharges. Accordingly, nitrate from lawn fertilization can be readily addressed or mitigated by modified practices and community best management practice education and so need not be included in the calculations above.

Density recommendations based on nitrate dilution rely on various fundamental hydrogeologic and operational assumptions. These are listed in detail in Chazen (2006a). Most are judged to fully apply to Philipstown and are reprinted here:

- Wastewater releases and on-site groundwater recharge occur in the same aquifer and at least seasonally there is a high likelihood of complete and uniform mixing of the two aspects. During wet periods, some components of wastewater and groundwater may leave sites as interflow, but during dry seasons, both components will fully mix in the common aquifer on or near the site. The model selected here may generally be considered to predict the average nitrate concentration in the aquifer at the downgradient property line.

- The only water available to dilute wastewater is on-site recharge. The assumption ignores mixing of the plume with upgradient groundwater since the calculation is intended for sub-regional applications (e.g. build-out, subdivision, or zoning district scale applications) where density cannot rely on other areas to provide necessary dilution water streams.

- Once in the aquifer, nitrate is effectively inert and not prone to decomposition by any methods. Dilution, therefore, is presently the most cost-effective quality management technique. This assumption would also apply to other wastewater constituents not prone to biological breakdown (e.g. pharmaceutical residues, caffeine, etc.), but the dilution calculations here have been applied only to nitrate. Within residential areas, nitrate is generally not selectively removed by root systems since upland depths to watertable during critical dry-season periods normally exceed at least 30 feet, only becoming shallower in riparian or near-wetland settings. A literature search indicates that denitrification from vegetation normally only occurs where the watertable is within 10 feet or less of grade (reported in Chazen, 2006a).

- There is a one-to-one correspondence between homes and disposal systems. Where community septic systems are used, the numbers of users per system can easily be adjusted in the model calculation.

- By adjusting the Impervious Surface Cover factor, the density calculation may be revised to address any beneficial on-site recharge design features (e.g. any Low Impact Development LID or other good design features which enhance on-site recharge) or revised to reflect precisely known or allowed impervious surface acreages from roofs, driveways and roadways. Where good design practices are used and storm drainage does not intentionally channel roof, driveway and other runoff away from the site, most precipitation may continue to recharge sites during lower-volume rain events by flowing to nearby lawn or natural areas to recharge the underlying aquifer.

- The model is not intended to accurately identify precise nitrate concentrations along groundwater flow paths, but rather to address broader impact estimates of regional use of conventional septic systems on aquifers also used to support domestic wells. The general assumptions are judged to model conservative and realistic average nitrate concentrations, but in doing so will underestimate nitrate concentrations immediately downgradient of a system leaching field and overestimate nitrate concentrations in areas most distant from a leaching field plume.

- The density recommendations found here do not preclude use of cluster subdivision models as recommended in many municipal zoning ordinances and Comprehensive Plans. As long as overall site density objectives are met, and with proper site design and engineering practices, the model will continue to manage groundwater nitrate concentrations while allowing clustered construction techniques. For example, in some cases, one could increase the length of casing for added protection if clustered wells and septic systems must lie near one another, or quality risks may be reduced by locating wells upgradient from septic systems, or wells may be sited in open space areas to protect well water quality.

- Although in summer very little aquifer recharge occurs which can dilute wastewater nitrate concentrations, groundwater moves very slowly so summer-time nitrate loads travel a long time before reaching a downgradient well. This travel time is usually longer than a full summer, so the autumn, winter, and spring wet periods provide the necessary recharge and nitrate dilution before a nitrate plume from one septic system will normally reach an adjoining downgradient well assuming typical geology and adherence to the average density recommendations found herein.

- This model does not address yield reliability of wells, focusing instead on recommending regional water balances needed to ensure potable groundwater quality. The effect of the model, however, is to recommend large enough parcel densities that recharge volumes needed for dilution purposes also exceed normally rates of well-water consumption, therefore effectively providing a measure of protection preserving most well yields during extended drought periods. In some cases, however, specific study will still be required to ensure that well capacity needs can be met on sites.

- Soil cover rather than bedrock formation is an effective predictor of net aquifer recharge. Surficial aquifers and other unconsolidated pore space provides temporary storage retaining groundwater over buried bedrock surfaces, facilitating recharge to the underlying deeper aquifer zones normally intersected by domestic wells. Neither recharge nor septic system wastewater releases are observed seeping directly into streams during dry periods, verifying that during all but the wettest periods, a majority of recharge passing through soils reaches the underlying aquifer.

- This study does not factor in changes in aquifer recharge that might be attributable to slopes. Recharge values during the low-intensity storms responsible for most aquifer recharge does not generate much runoff so even precipitation on steep slopes is able to penetrate into the ground.

- No correction factors have been applied to calibration data to account for existing land uses. This is because the vast majority of land uses in Philipstown remain substantially in conditions of open land or residential development with impermeability coverage of less than 15 percent. Overall runoff volumes generally do not substantially increase relative to pre-development natural conditions during the more routine rainfalls events of under 1.25 inch which provide up to 80 percent of annual recharge (Chazen, 2006b). Until regional impervious surface coverage increases markedly, soil infiltration capacity rather than present land uses is judged to be the principal ranking parameter for recharge capacity.

- This investigation does not include overt factors for evaluating the potential impacts of global warming. If, as has been outlined and/or predicted in other professional literature, future rainfall patterns become more torrential with longer periods without precipitation between heavy rains, recharge rates will decline since a majority of present recharge is normally attributed to less torrential rainfalls. The present model is nonetheless somewhat conservative in its use of a 5.0 mg/l nitrate planning target, allowing some latitude to compensate for precipitation pattern changes; however, the present recommendations may cease to be adequately protective of the quality of groundwater if extreme weather pattern shifts occur.

- Approximately 2 percent of lands in Philipstown, including the Villages of Cold spring and Nelsonville have received no Hydrologic Soil Group assignment. In such areas, this study has assumed that the recharge rate may lie mid-way between the most common Hydrologic Soil Groups B and C, as an average value.

4.3 Aquifer Protection

Approximately half of the residents in Philipstown rely on individual wells which are not required to be routinely sampled or provided any systematic water quality protection. Since residential wells are in use throughout nearly all of Philipstown, this study recommends adoption of a townwide aquifer overlay protection ordinance to provide a measure of groundwater quality protection in the community.

A model aquifer ordinance potentially suitable to be adapted to Philipstown is included in Appendix C. The ordinance was developed by four towns in Dutchess County and the Dutchess County Water & Wastewater Authority and has received careful legal review to verify municipal authority on all addressed topics. The particular version of this model provided in Appendix C is under consideration for adoption in the Town of Amenia Dutchess County and could be readily adapted for use in Philipstown.

Briefly, the advantages of this type of aquifer protection model include:

1. Some measure of aquifer protection is provided for all lands in the Town.

2. The model provides both groundwater quality and groundwater capacity protection. Proposed activities requiring more water than that recharged on the individual site is accorded a higher level of SEQRA review.

3. The highest level of aquifer protection is directed at high quality or high-use aquifer areas, and to wellhead protection areas for community wells. More flexible aquifer protection is recommended for all other areas.

Plate 2 provides a recommended draft aquifer overlay map for the Town of Philipstown showing a Clove Creek Aquifer area. The entire town is shown lying within a Regional Aquifer (RA) district for which a general level of aquifer protection would be warranted. Within the recommended RA district, the map also delineates a Clove Creek Aquifer (CCA) area. A higher level of aquifer protection is recommended for the CCA area because it has particular potential to support high-capacity wells, no public water districts exist, and zoning allows a wide range of uses. The higher level of aquifer protection recommended for the CCA does not seem as necessary in other heavily settled Town areas such as Cold Spring, Nelsonville or eastern parts of Continental Village since these each receive water from central water supplies from surfacewater sources, rather than being reliant on local groundwater wells.

If the recommendation to include this priority aquifer area is accepted, the first portion of Section B1 of the Appendix C text could be revised as follows:

> 1. The Aquifer Overlay (AQO) District encompasses the entire Town of Philipstown and includes two basic types of aquifers: the Clove Creek Aquifer (CCA) area which is extensively developed and fully dependent on groundwater as a source of water supply, and the townwide Regional Aquifer (RA) area where groundwater is also used extensively but the land isless developed than in the CCA or where surface water is used as a source of water supply. The two AQO districts may include future internal aquifer zones, including Buffered Clove Creek Aquifer (BCCA) areas for the service areas of any regionally significant public water supplies developed within the CCA, and Regional Aquifer Wellhead Protection (RAWP) areas where wellhead protection could be provided for any community water system wellfields in the RA.

If these application and aquifer protection concepts are accepted by the Town, the rest of the model ordinance would need to be changed to match the terminology suggested above. If community water system wellfields are ever developed in the RA or if a regionally-significant water district is ever developed in the CCA, the Plate 2 aquifer map can be revised to map such wellhead recharge areas and water district service areas.

Included within the recommended Regional Aquifer are various low-intensity land uses, including State Parks. The recommended land use controls applicable to such areas within the RA area would impose minimal restrictions.

4.4 Pumping Test Protocols

Where subdivisions are proposed using individual wells and septic systems and if zoning isn't changed to prevent allowable parcel sizes smaller than those recommended in Section 4.2, aquifer pumping test protocols more advanced than those required by the Putnam County Department of Health are recommended. The Putnam County Department of Health currently requires only pre-installation and testing of 10% (1 in 10) of proposed wells on such subdivisions. Testing of such wells may be conducted individually and the tests usually last less than one day. By means of a local ordinance or a strongly recommended guidance administered by the Planning Board, this study recommends that where parcel sizes are smaller than those recommended by this study, the testing of all pre-drilled individual wells be extended at least to 24 hours, and potentially to as long as 72-hours if particularly sensitive on-site or off-site conditions are identified by the reviewing board. The discharge rate for testing of each pre-drilled well should be a minimum of 5 gallons per minute (gpm), and if more than one well has been pre-drilled because of the size of the proposed subdivision, all testing should be conducted simultaneously in all wells.

Where wells are installed for a new community water supply, wells may continue with presently required protocols. Wells intended for such uses are required to undergo testing for at least 72 hours at pumping rates equal to twice the average estimated daily demand rate. Off site monitoring of existing wells, streams and wetlands should normally be required by the Planning Board as a SEQRA consideration. Applicants should also be required to evaluate and address the water supply requirements of any well sites already permitted for construction even if they have not yet been constructed. The 72-hour test protocol used for most community water systems is inherently conservative since the test is conducted at twice average daily demand and so is likely to successfully identify groundwater shortages in a project area. The report prepared describing a completed pumping test should include a groundwater recharge budget for the aquifer close to the project site, explaining the source of water which will supply the project water, and the test results should include drawdown projections showing how low water levels will fall in water supply wells during extended dry periods of up to 180 days.

Present testing protocols for non-community wells are believed to be reasonably conservative and no changes are recommended.

4.5 Road De-Icing

Salt is a regionally-recognized groundwater contaminant. Chloride contamination in wells has been documented in many towns in the Hudson Highlands. Road salt is a primary source of salt in groundwater. Water softener salt discharges can also contaminate wells.

Subdivisions with individual wells should include impervious snow accumulation areas for ends of roads or other areas likely to accumulate particularly large snow volumes. In addition to ends of cul-de-sacs, snow accumulation or salt runoff accumulation can occur in wells found at the bottom of hills or immediately downhill from a road margin. Use of impervious snow accumulation areas connected to effective runoff-control ways will ensure that salt crystals do not accumulate in soils during the winter to dissolve later, and will ensure that that salt-laden melt-water will be conveyed away from or past any individual wells. Select areas may be identified as being sufficiently vulnerable to road salt contamination of groundwater resources and wells that "no salt" road segments may need to be designated. Infiltration practices introducing road runoff directly into aquifers should be discouraged.

Protocols developed by the NYS Department of Transportation can be used to help distinguish between road salt and water softener contamination in wells.

4.6 Wastewater Management

Topography and historic settlement patterns have led to the development of various small neighborhood areas distributed throughout Philipstown. Some may warrant close review of wastewater management techniques to prevent well water or surfacewater contamination from septic systems.

Appendix B reviews a range of traditional and non-traditional wastewater treatment service which could be used in community centers or business areas in Philipstown. Increasingly, use of small-diameter sewer lines, community septic fields, and enhanced individual or small-group treatment systems can be cost-effective for wastewater management. The new technologies open the possibility for economically viable wastewater system design in small hamlets such as Garrison or areas along the Clove Creek/Route 9 corridor, or in cluster subdivisions.

5.0 REFERENCES

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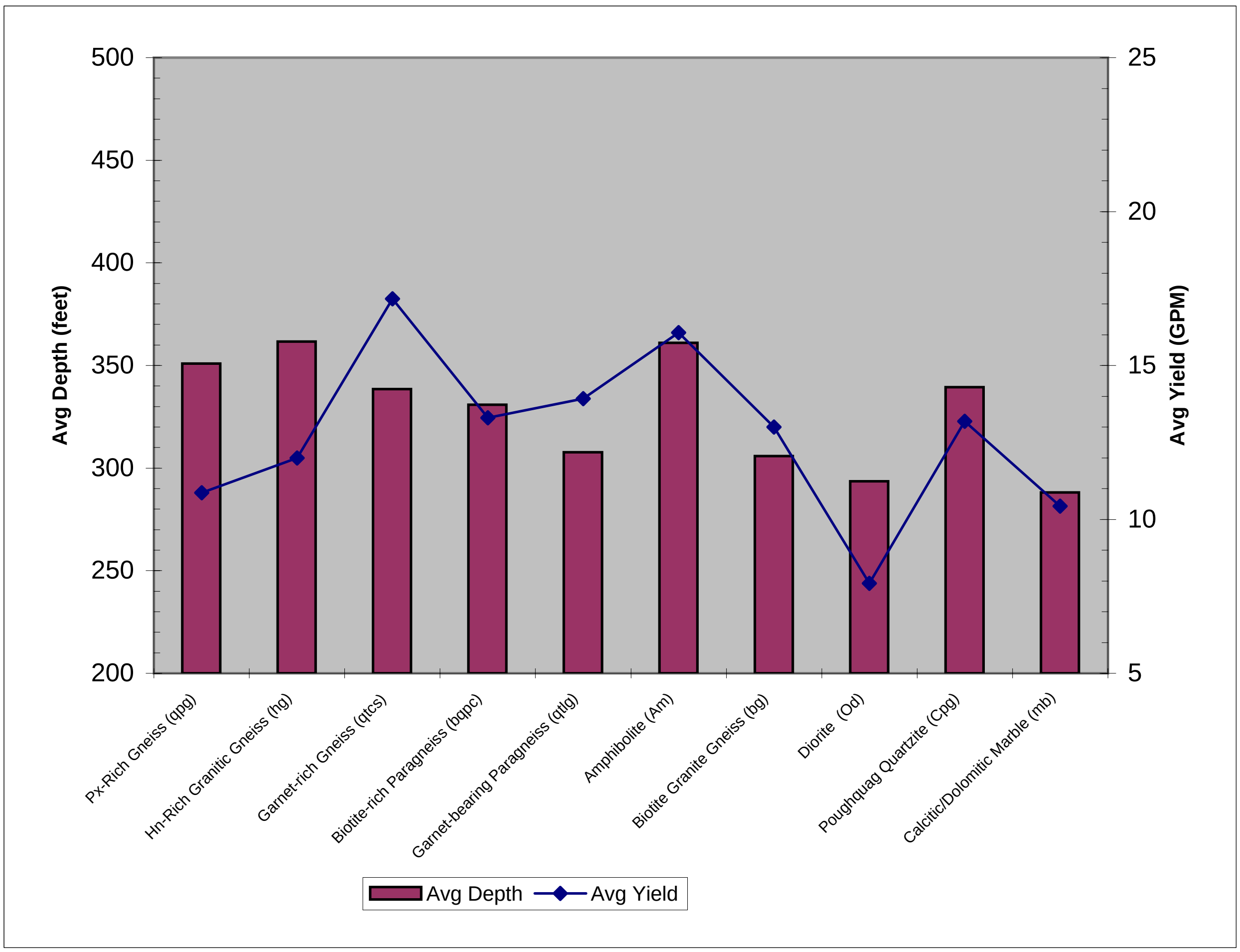
Tables

Table 1 - Well Statistics
Depth and Yield by Bedrock Formation

Bedrock Formation Statistics			***Yield***			***Depth***		
Philipstown, NY	Number	Percent	Average	Median	Mode	Average	Median	Mode
Px-Rich Gneiss (qpg)	95	1.70	10.87	7	5	350.94	325	130
Hn-Rich Granitic Gneiss (hg)	3	0.05	12	10	NA	361.67	400	NA
Garnet-rich Gneiss (qtcs)	63	1.13	17.17	8	5	338.57	320	426
Biotite-rich Paragneiss (bqpc)	1817	32.53	13.3	8	5	330.95	300	300
Garnet-bearing Paragneiss (qtlg)	236	4.22	13.92	10	10	307.78	281	200
Amphibolite (Am)	1118	20.01	16.07	10	5	361.11	300	205
Biotite Granite Gneiss (bg)	1624	29.07	13	8	5	305.86	275	200
Diorite (Od)	13	0.23	7.92	9	5	293.5	260	200
Poughquag Quartzite (Cpg)	21	0.38	13.19	8	5	339.4	300	300
Calcitic/Dolomitic Marble (mb)	21	0.38	10.43	10	10	288.07	300	200



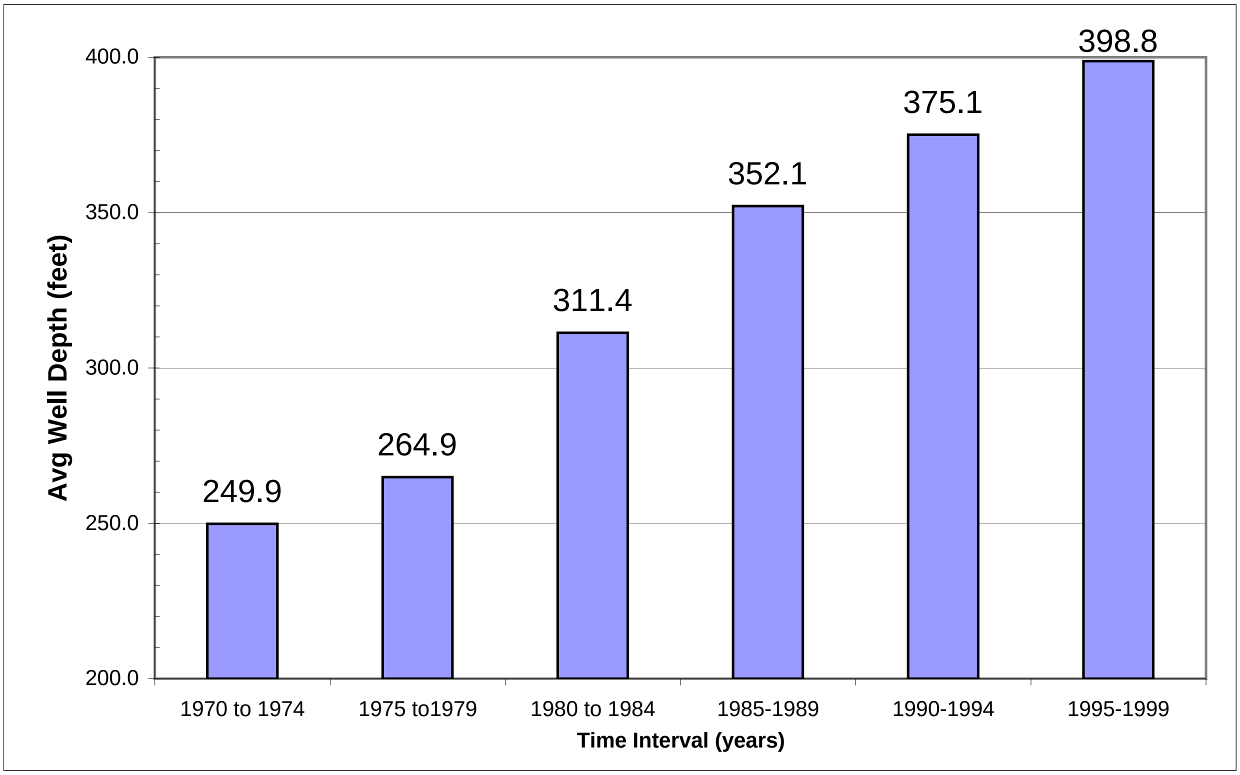
These data describe typical yields & depths for wells installed in geologic formations throughout Putnam County. Only bedrock geologic formations found in Philipstown are shown.

Ranges of yields & depths vary from dry wells to yields over 100 gpm, and depths may range from less than 100 feet to over 800 feet. The analysis helps identify higher and lower yielding geologic formations.

Source: Chazen, 2004

Table 2 - Well Statistics
Well Depth and Yield Trends

Well Statistics for Time Periods			***Yield***		***Depth***
Time Period	***Number***	***Percent***	***Average***	***Median***	***Average***
1965 to 1970	1	0.0	NA	NA	NA
1970 to 1974	824	15.3	13.66	8	249.9
1975 to1979	680	12.6	12.60	8	264.9
1980 to 1984	538	10.0	15.40	10	311.4
1985-1989	1484	27.5	16.45	10	352.1
1990-1994	833	15.5	10.85	7	375.1
1995-1999	920	17.1	16.60	10	398.8
2000 to 2003	109	2.0	14.01	10	383.1
Total:	*5389*	*100*			



This analysis indicates that newer wells are being drilled deeper than older wells. This is interpreted to be the result of new construction occurring in less accessible locations, changed drilling methods commonly leadeing to deeper well drilling, and

Source: Chazen, 2004

Table 3 - Natural Groundwater Quality in Various Aquifer Formations* (in ppm except pH)

	Granite and gneiss, undifferentiated		Pochuck diorite		Walloomsac Hudson River formation		Inwood/Wappinger Stockbridge limestone		Unconsolidated deposits overlying limestone		Unconsolidated deposits overlying granite, gneiss, diorite, and schist	
	Median and range	Number of analyses	Median and range	Number of analyses	Median and range	Number of analyses	Median and range	Number of analyses	Median and range	Number of analyses	Median and range	Number of analyses
Iron (Fe)	0.20 0.02-2.5	56	0.13 0.01-2.5	9	0.29 0.10-3.0	10	0.10 0.03-.17	7	0.10 0.03-.60	11	0.11 0.0-1.4	36
Sulfate (SO_4)	15 5.0-44	36	20 7.8-26	5	16 5.8-209	12	25 4-182	8	14 8.0-46	10	17 6-29	23
Chloride (Cl)	4.0 .8-29	69	8.7 4.8-37	8	2.4 .8-19	12	3.6 2.0-17	8	7.0 1.0-29	11	3.2 1.2-55	37
Nitrate (NO_3)	.5 .0-12	31	7.6 1.3-13	4	12 --	1	.6 --	1	3.5 --	1	.9 .0-12	13
Dissolved solids	120 43-255	17	132 69-256	7	143 52-370	11	293 198-513	3	503 74-600	5	130 36-258	19
Total hardness (as $CaCO_3$)	72 16-390	73	63 12-156	10	99 38-280	12	176 140-236	7	220 46-290	11	75 18-160	38
Carbonate hardness	52 6-307	68	44 12-123	8	78 12-144	12	160 140-218	7	188 18-399	11	65 4-213	37
Noncarbonate hardness	14 0-99	72	28 0-55	8	13 0-262	12	12 0-20	7	11 0-81	11	10 0-126	37
pH	7.0 5.6-9.8	70	6.8 6.2-7.6	10	7.3 6.2-8.0	12	7.6 7.2-8.1	8	7.2 6.9-7.5	11	6.9 6.0-8.1	37

*from Grossman, I.G., 1957, The Ground Water Resources of Putnam County, New York, USGS, Bulletin GW-37

Figures

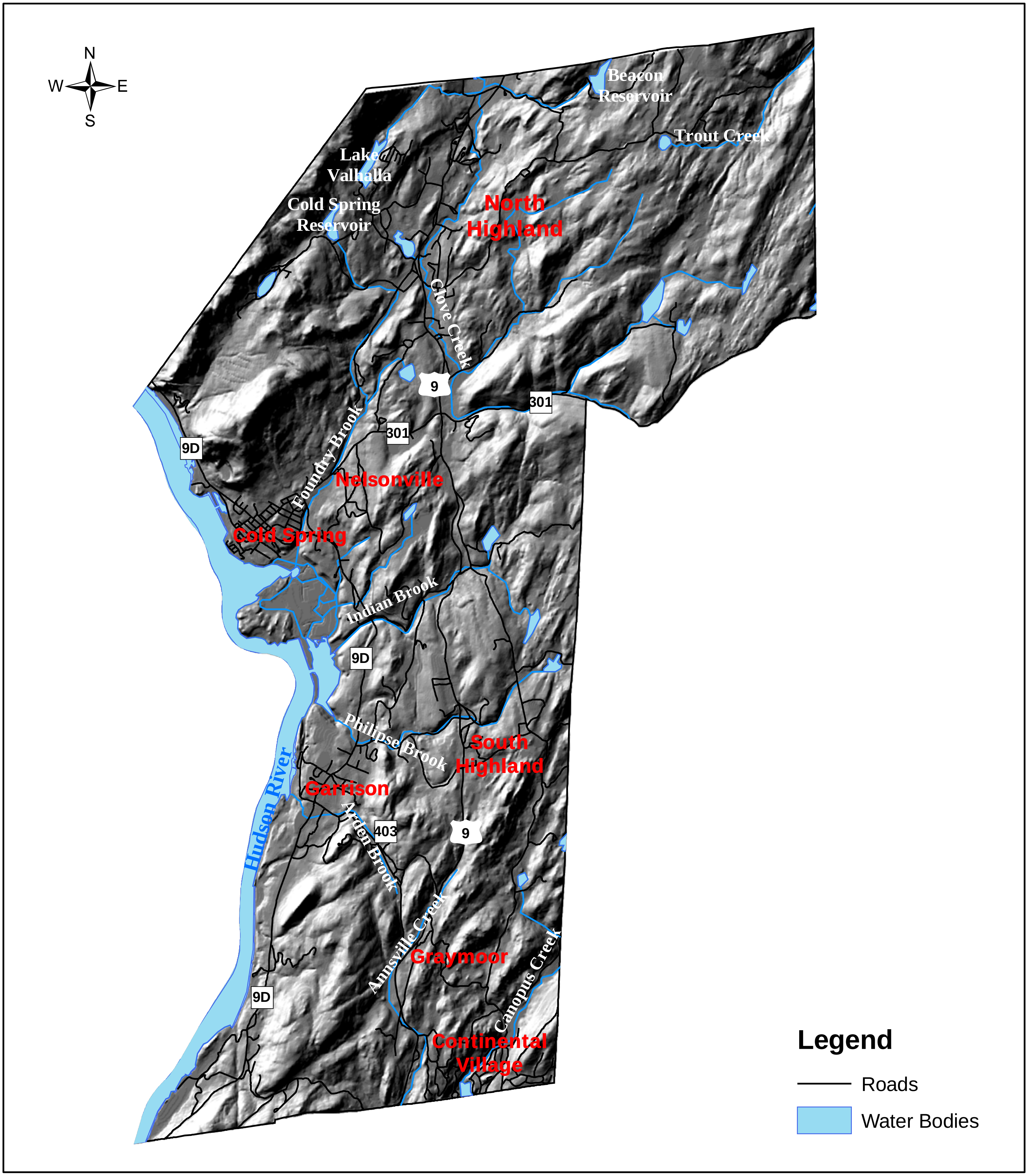


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FIGURE 1 - HILLSHADE SITE REFERENCE MAP

Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

Source: TCC GIS Database for Putnam County

Date:	June 2007
Scale:	1 in equals 7,500 ft
Project #:	40605.00

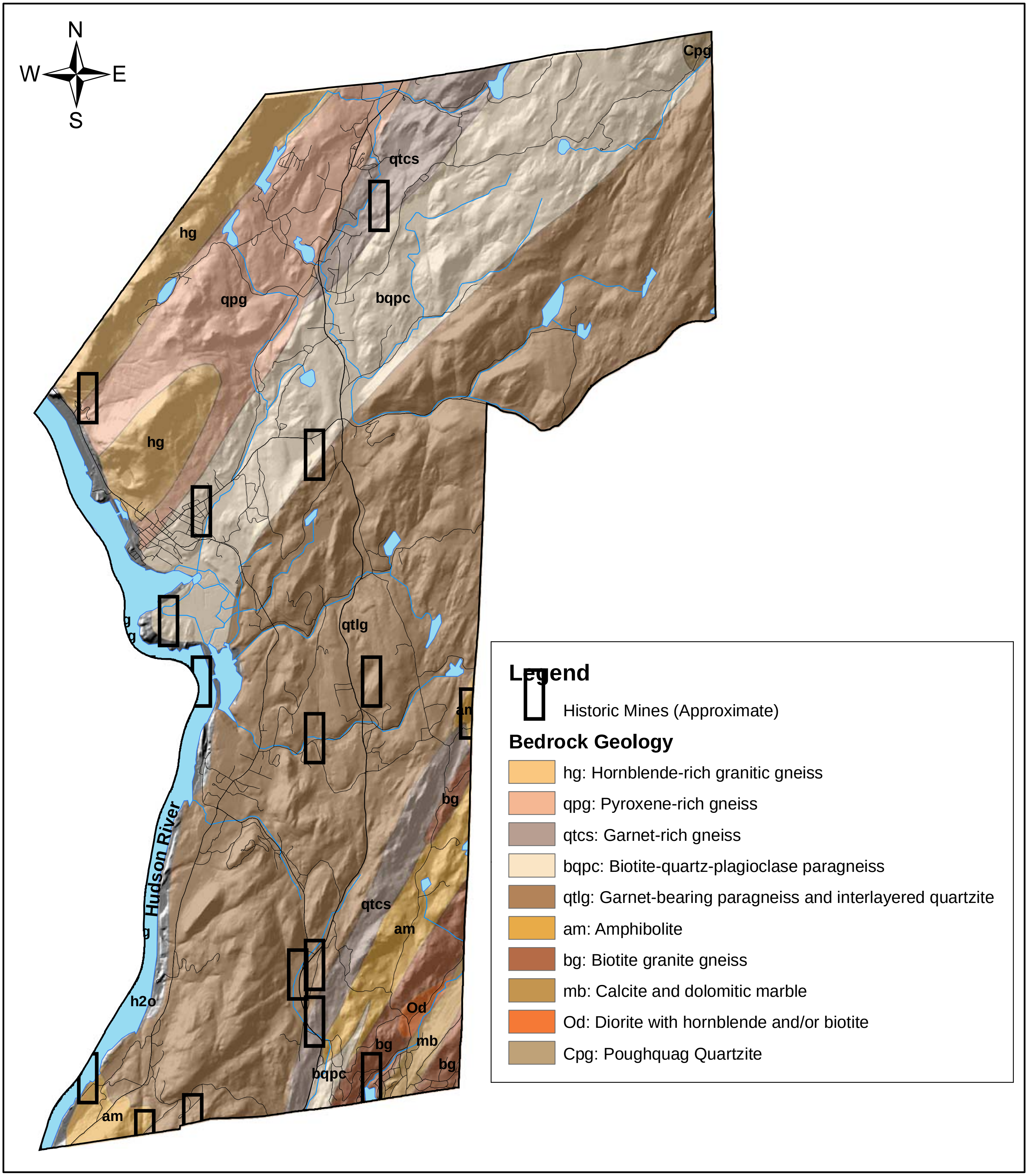

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FIGURE 2-BEDROCK GEOLOGY

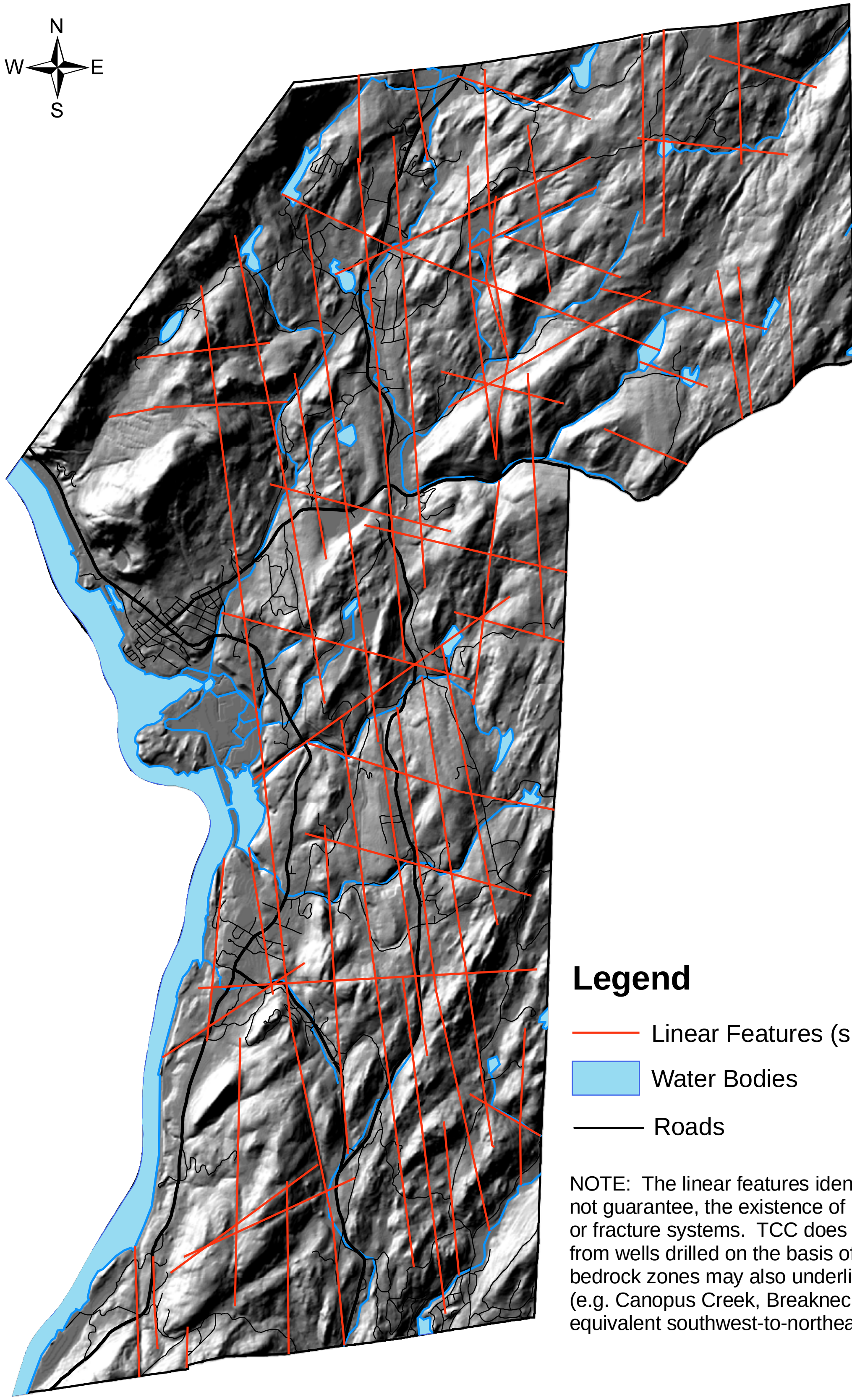
Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

Sources: Bedrock Geology from NYSGS Bedrock Geology Map, Lower Hudson Sheet, Dated 1970, Reprinted 1995; Mine Locations from TCC, 2004.

Date:
June 2007

Scale:
1 in equals 7,500 ft

Project #:
40605.00



Legend

- Linear Features (suggestive of underlying fractures)
- Water Bodies
- Roads

NOTE: The linear features identified on this map suggest, but do not guarantee, the existence of underlying water-bearing fractures or fracture systems. TCC does not guarantee water production from wells drilled on the basis of these feature locations. Fractured bedrock zones may also underlie prominent valley alignments (e.g. Canopus Creek, Breakneck Brook, Foundry Brook) and equivalent southwest-to-northeast valleys.

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FIGURE 3 - PRELIMINARY FRACTURE TRACE MAP

Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

Source: Linear features mapped by The Chazen Companies, 2007.

Date: June 2007	
Scale: 1 in equals 7,500 ft	
Project #: 40605.00	

Figure 4A - Interpreted from Soil Survey

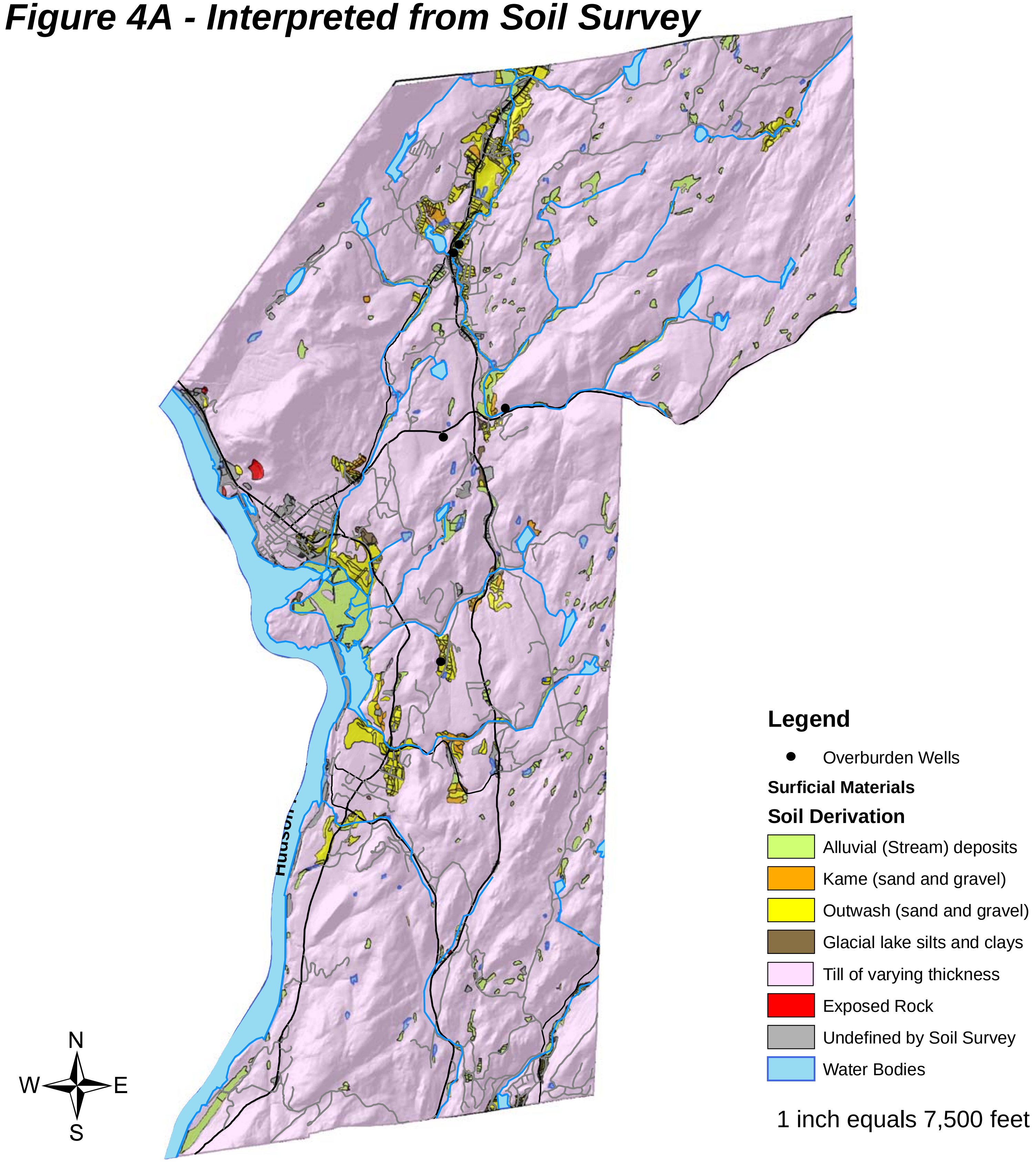
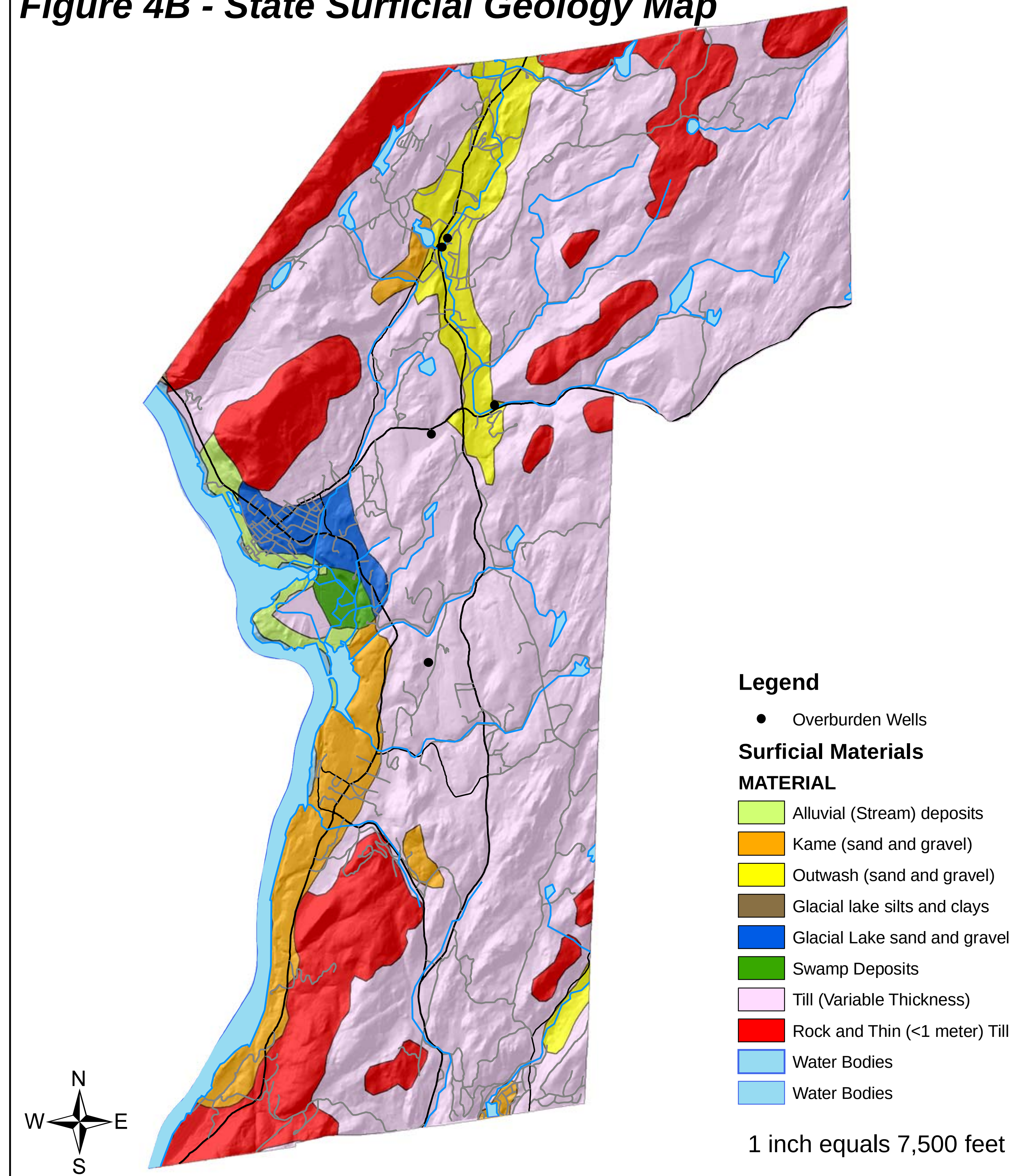


Figure 4B - State Surficial Geology Map



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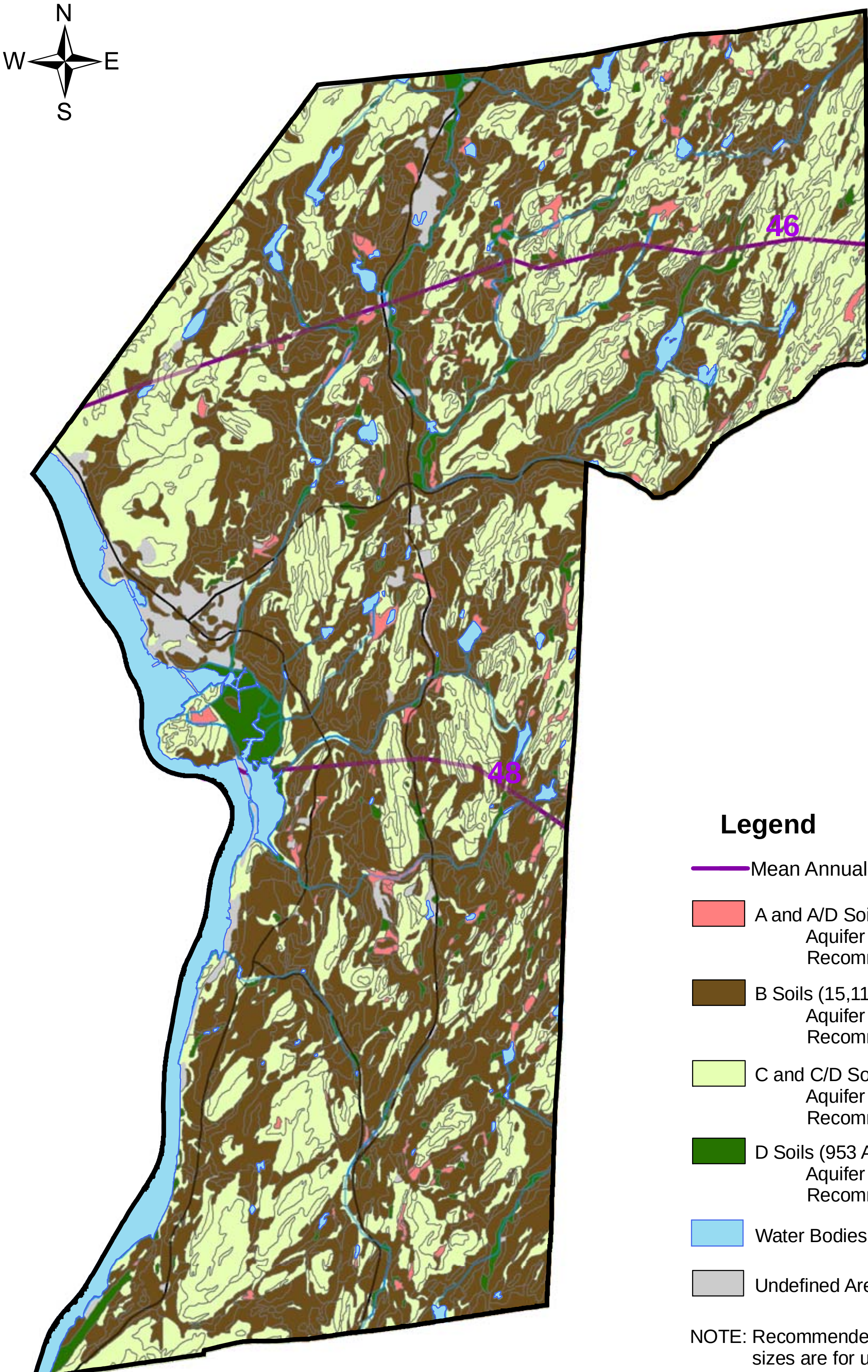
NOTE: Overburden wells are those wells which the Putnam County well log database indicates draw water from surficial deposits rather than underlying bedrock materials.

FIGURES 4A, 4B - SURFICIAL GEOLOGY MAPS

Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

Sources: Figure 4A derived by TCC from USDA Soil Survey of Putnam and Westchester Counties, 1994; Figure 4B from NYSGS Surficial Geology Map, Lower Hudson Sheet, 1989.

Date: June 2007	
Scale: As Noted	
Project #: 40605.00	



Legend

Mean Annual Precipitation (Inches)

A and A/D Soils (570 Acres)
Aquifer Recharge: 20.2 Inches/Year
Recommended Min. Avg. Parcel Size: 1.2 Acres

B Soils (15,117 Acres)
Aquifer Recharge: 14.7 Inches/Year
Recommended Min. Avg. Parcel Size: 1.6 Acres

C and C/D Soils (13,932 Acres)
Aquifer Recharge: 7.6 Inches/Year
Recommended Min. Avg. Parcel Size: 3.0 Acres

D Soils (953 Acres)
Aquifer Recharge: 4.2 Inches/Year
Recommended Min. Avg. Parcel Size: 5.4 Acres

Water Bodies (1,810 Acres)

Undefined Area (736 Acres)

NOTE: Recommended minimum average parcel sizes are for usage of wells and septic systems.

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FIGURE 5 - HYDROLOGIC SOIL GROUP MAP AND PRECIPITATION ISOPLETHS

Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

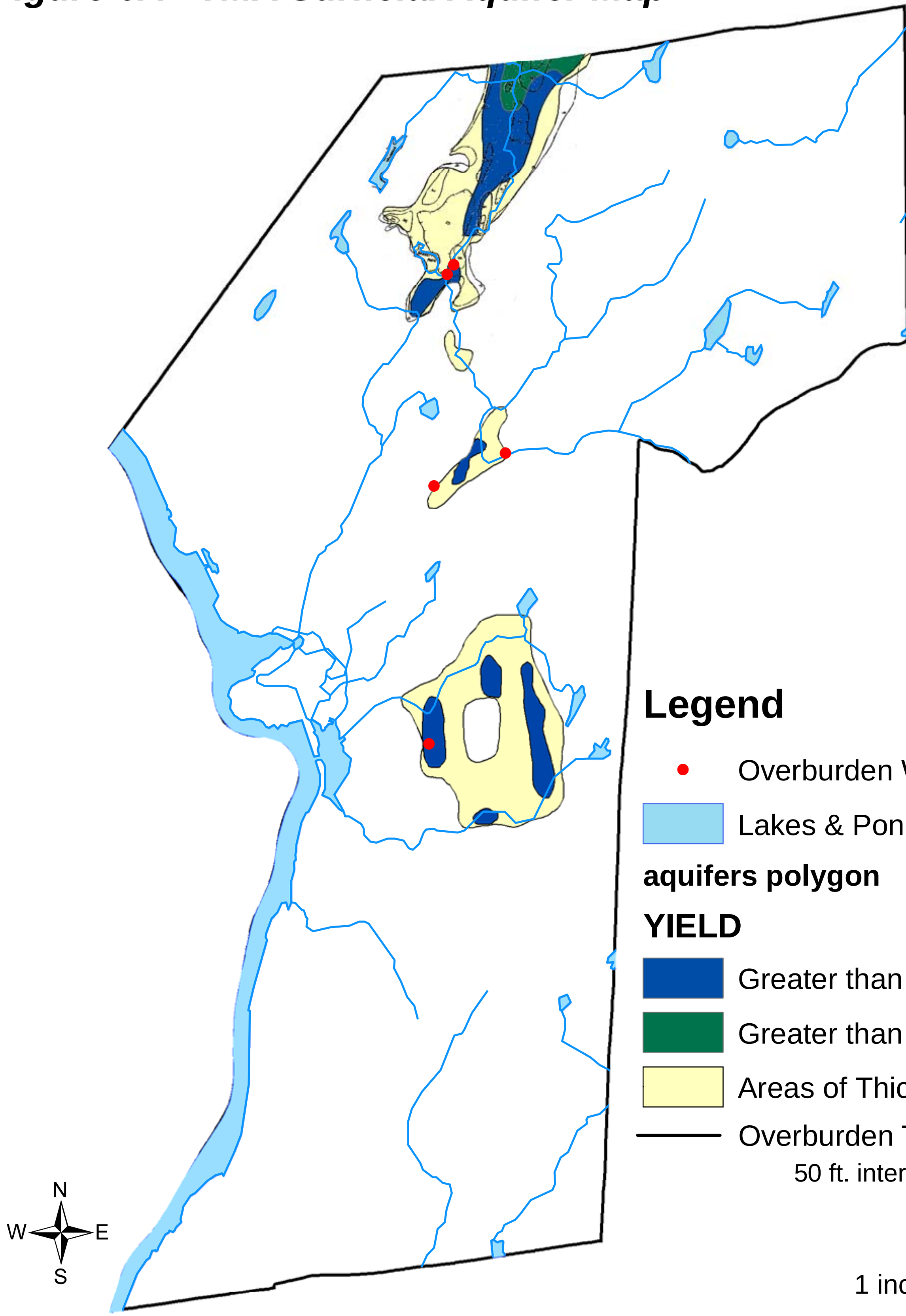
Source: Annual precipitation isopleths from Randall, 1996; Hydrologic Soil Groups from USDA Soil Survey of Putnam and Westchester Counties, 1994.

Date:
June 2007

Scale:
1 in equals 7,500 ft

Project #:
40605.00

Figure 6A - TMA Surficial Aquifer Map



Legend

- Overburden Wells
- Lakes & Ponds

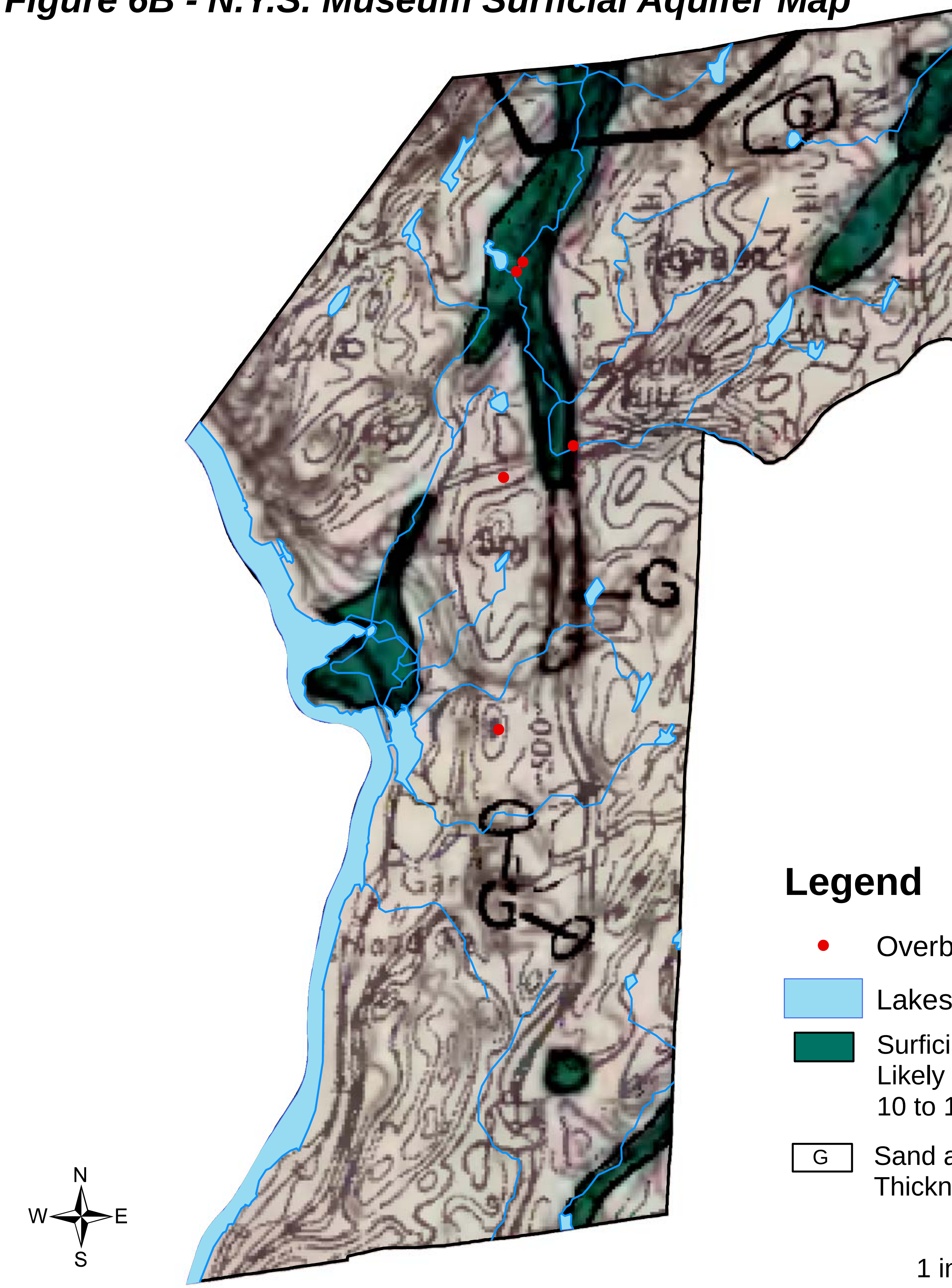
aquifers polygon

YIELD

- Greater than 20 GPM
- Greater than 50 GPM
- Areas of Thick Overburden
- Overburden Thickness Contours
  50 ft. interval

1 inch equals 7,500 feet

Figure 6B - N.Y.S. Museum Surficial Aquifer Map



Legend

- Overburden Wells
- Lakes & Ponds
- Surficial Aquifer Areas Likely to Produce 10 to 100 gpm
- G Sand and Gravel Deposits Thickness & Yield Unknown

1 inch equals 7,500 feet

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547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

NOTE: Overburden wells are those wells that the Putnam County well log database indicates draw water from surficial deposits rather than underlying bedrock materials.

FIGURES 6A, 6B - PREVIOUS AQUIFER MAPPING

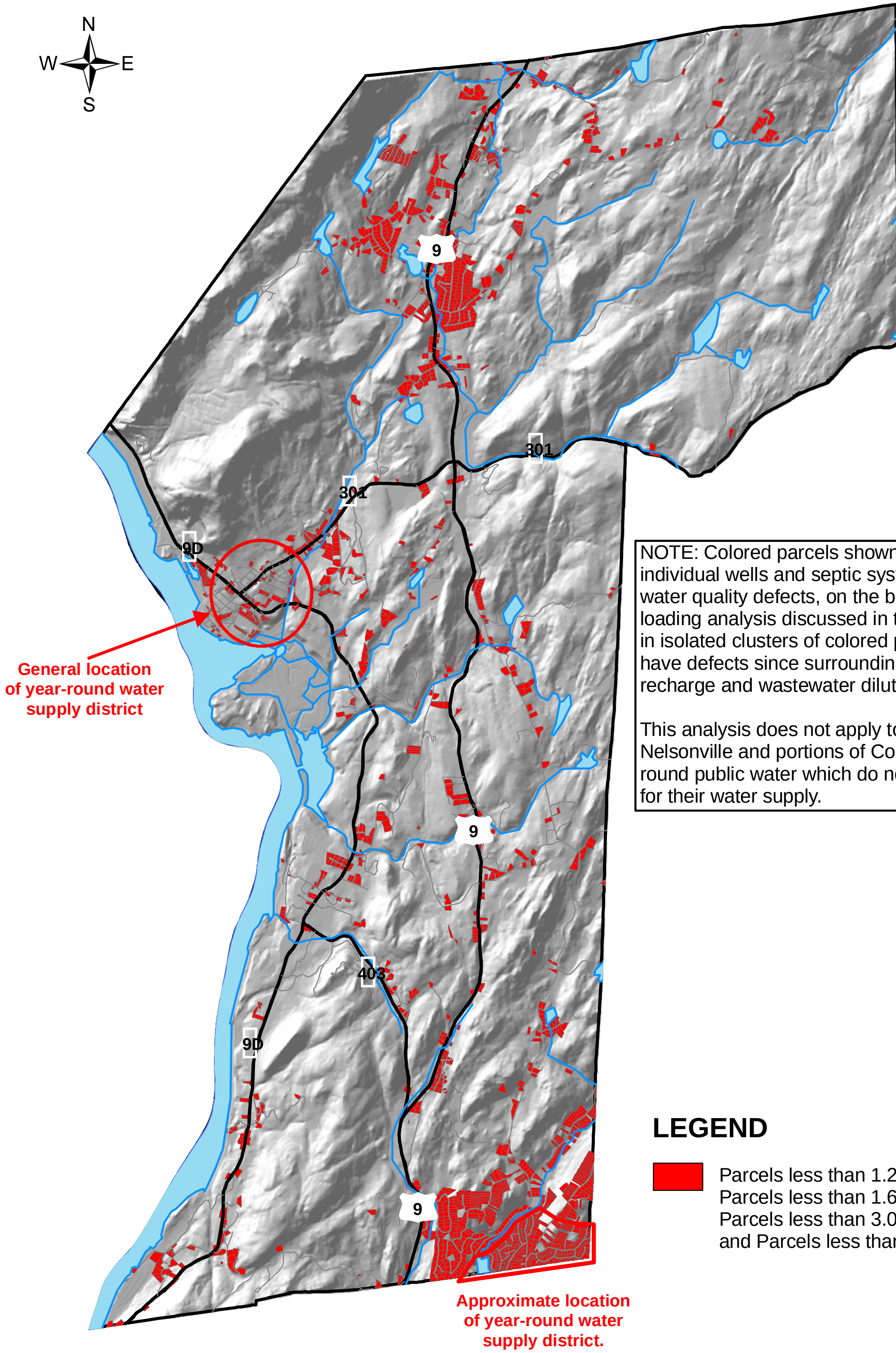
Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

Figure 6A from Tim Miller Associates, Inc. mapping, 1991;
Figure 6B from N.Y.S. Museum, Bugliosi and Trudell Aquifer Map, 1987.

Date:
June 2007

Scale:
As Noted

Project #:
40605.00



NOTE: Colored parcels shown on this figure, which rely on individual wells and septic systems, may be experiencing water quality defects, on the basis of septic system wastewater loading analysis discussed in the attached report. Wells in isolated clusters of colored parcels are only slightly likely to have defects since surrounding lands provide compensatory recharge and wastewater dilution opportunities.

This analysis does not apply to the parcels within Cold Spring, Nelsonville and portions of Continental Village receiving year-round public water which do not rely on groundwater wells for their water supply.

LEGEND

Parcels less than 1.2 acres with Group A or A/D soils,
Parcels less than 1.6 acres with Group B soils,
Parcels less than 3.0 acres with Group C or D/D soils
and Parcels less than 5.4 acres with Group D soils

THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

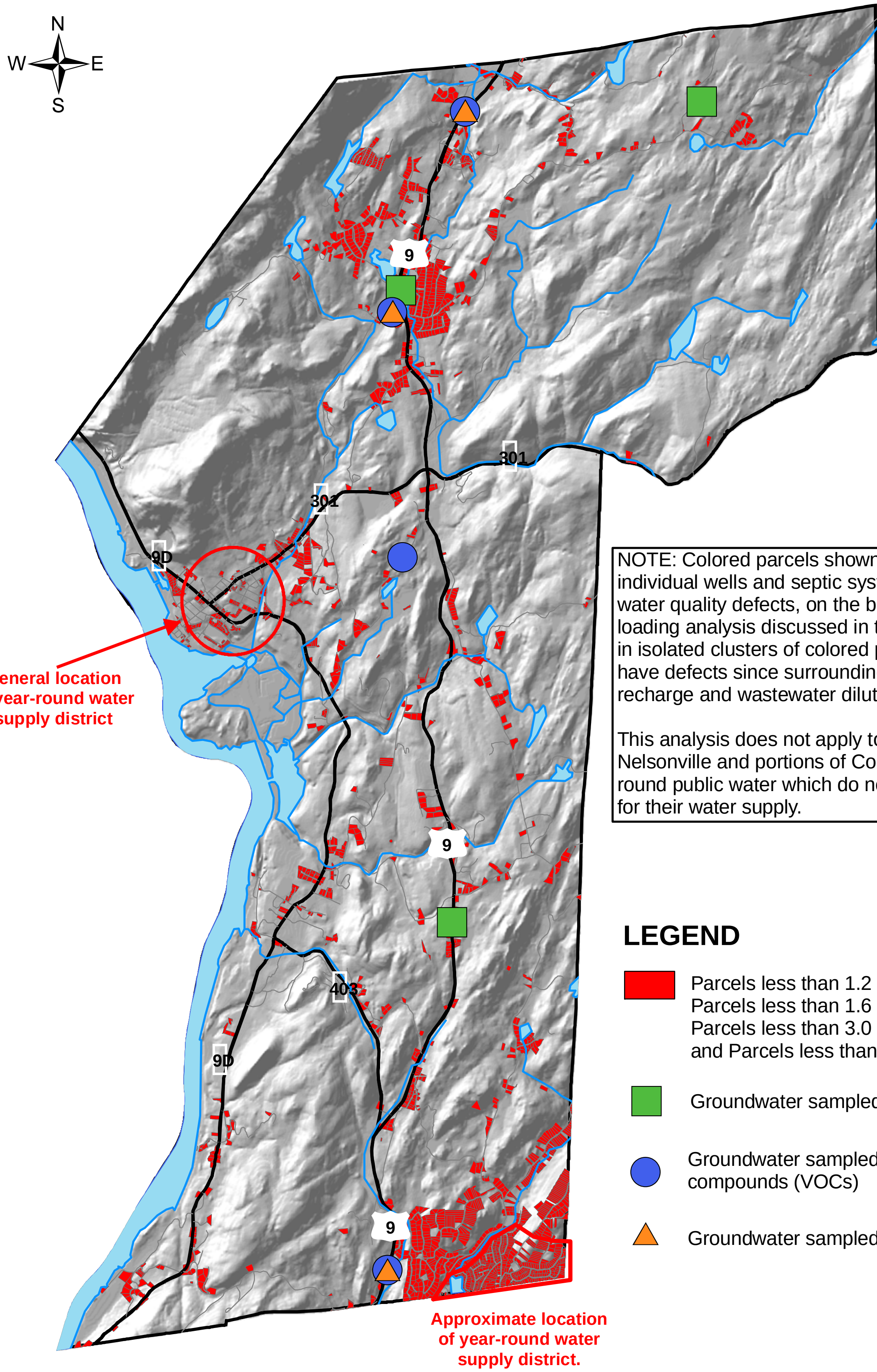
Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 7 - HYDROLOGIC SOIL GROUPS WITH RECOMMENDED MINIMUM AVERAGE SEPTIC SYSTEM SIZES
Town of Philipstown, Villages of Cold Spring and Nelsonville
Putnam County, New York
Sources: TCC GIS Database for Putnam County, USDA Soil Survey of Putnam and Westchester Counties, 1994.

Date:
June 2007

Scale:
1 in equals 7,500 ft

Project #:
40605.00



NOTE: Colored parcels shown on this figure, which rely on individual wells and septic systems, may be experiencing water quality defects, on the basis of septic system wastewater loading analysis discussed in the attached report. Wells in isolated clusters of colored parcels are only slightly likely to have defects since surrounding lands provide compensatory recharge and wastewater dilution opportunities.

This analysis does not apply to the parcels within Cold Spring, Nelsonville and portions of Continental Village receiving year-round public water which do not rely on groundwater wells for their water supply.

LEGEND

- Parcels less than 1.2 acres with Group A or A/D soils, Parcels less than 1.6 acres with Group B soils, Parcels less than 3.0 acres with Group C or D/D soils and Parcels less than 5.4 acres with Group D soils
- Groundwater sampled for Radon
- Groundwater sampled for volatile organic compounds (VOCs)
- Groundwater sampled for Nitrate and Sodium Chloride

THE Chazen COMPANIES

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547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

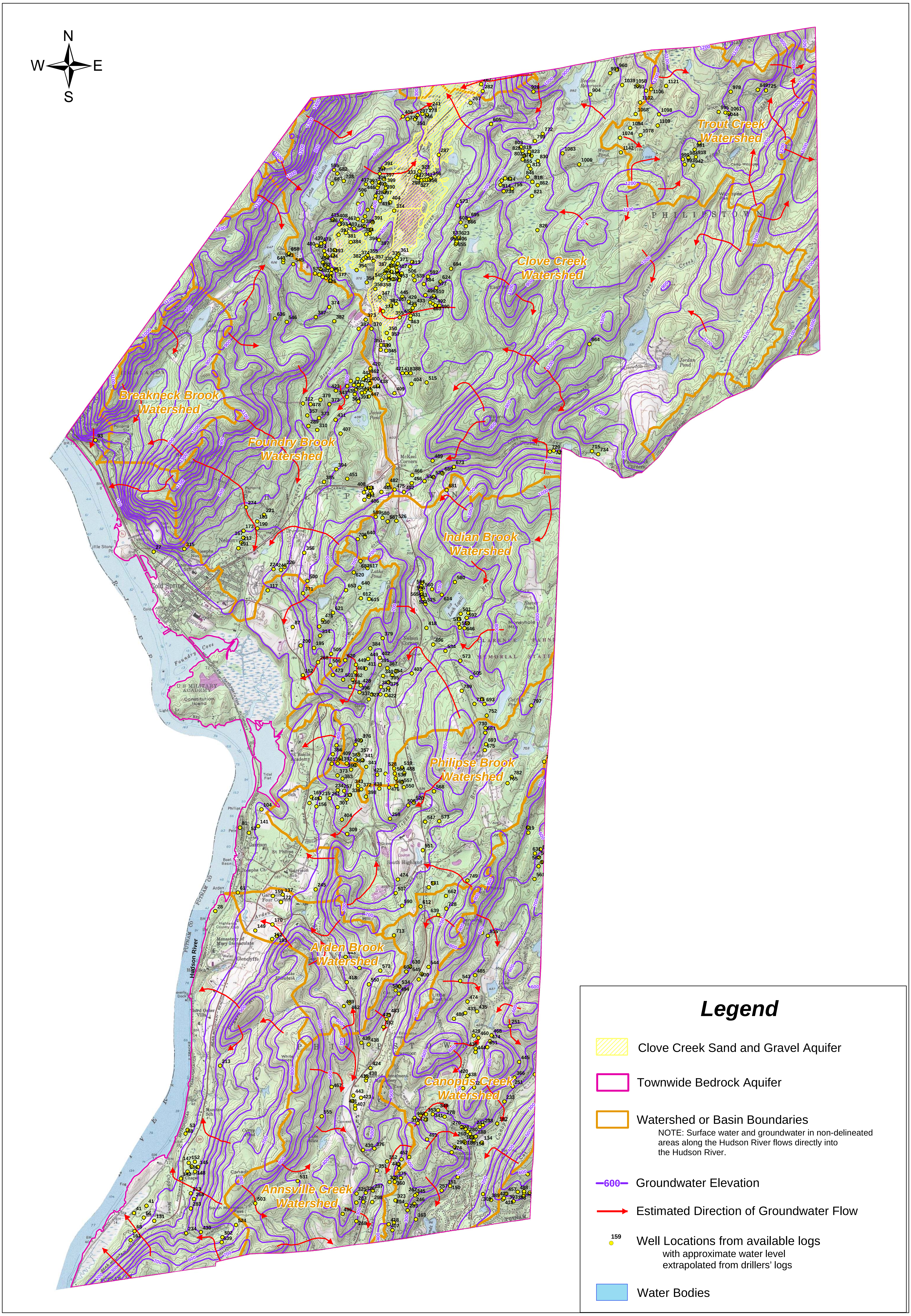
FIGURE 8 - GROUNDWATER SAMPLING LOCATIONS

Town of Philipstown, Villages of Cold Spring and Nelsonville
Putnam County, New York

Sources: TCC GIS Database for Putnam County, USDA Soil Survey of Putnam and Westchester Counties, 1994.

Date:	June 2007
Scale:	1 in equals 7,500 ft
Project #:	40605.00

Plates



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
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Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

PLATE 1 - AQUIFER MAP

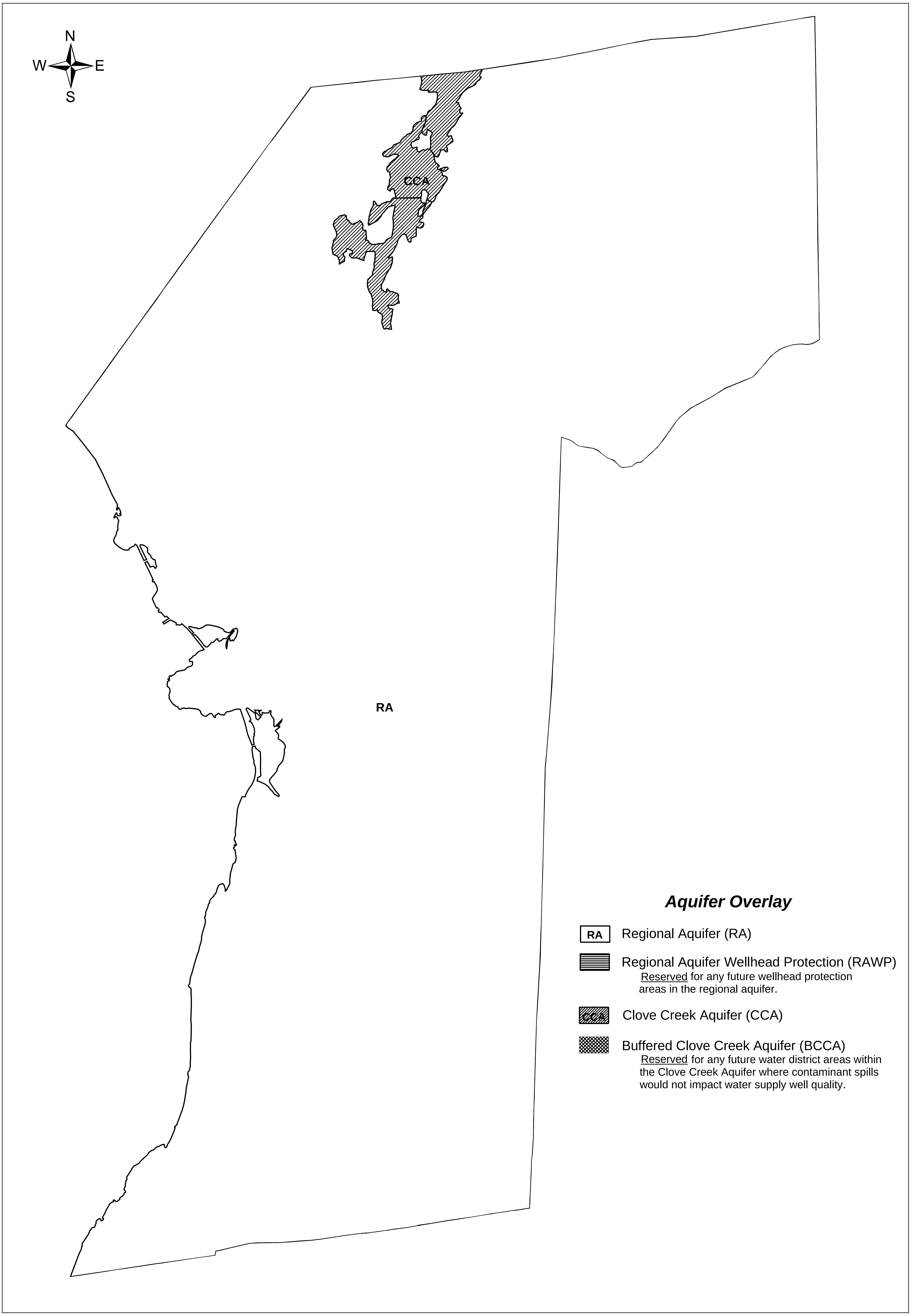
Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

USGS Topographic Maps of the Oscawana Lake, West Point and Peekskill Quadrangles, 7.5 Minute Series, Dated 1956, 1957 and 1957. Groundwater contours, groundwater flow direction, watershed boundaries and estimated groundwater levels in wells developed and/or mapped by the Chazen Companies, 2006-2007. Well locations plotted from the Putnam County Well Log Database. Surficial aquifer area derived by TCC from the USDA Soil Survey of Putnam and Westchester Counties, 1994.

Date:
June 2007

Scale:
1 in equals 2,250 ft

Project #:
40605.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

PLATE 2 - DRAFT AQUIFER OVERLAY MAP

Town of Philipstown, Villages of Nelsonville and Cold Spring
Putnam County, New York

Surficial Aquifer area derived by The Chazen Companies from the USDA Soil Survey of Putnam and Westchester Counties, 1994.

Date:
June 2007

Scale:
1 in equals 2,250 ft

Project #:
40605.00

Appendices

Appendix A

YORK
ANALYTICAL LABORATORIES, INC.

Technical Report

prepared for

Chazen Environmental Services
21 Fox Street
Poughkeepsie, NY 12601
Attention: Russell Urban Mead

Report Date: 2/12/2007
Re: Client Project ID: Town of Phillipstown / #40605 – Task 5
York Project No.: 07020080

CT License No. PH-0723 New York License No. 10854

nelac nelap

120 RESEARCH DRIVE STRATFORD, CT 06615 (203) 325-1371 FAX (203) 357-0166

Report Date: 2/12/2007
Client Project ID: Town of Phillipstown / #40605 – Task 5
York Project No.: 07020080

Chazen Environmental Services
21 Fox Street
Poughkeepsie, NY 12601
Attention: Russell Urban Mead

Purpose and Results

This report contains the analytical data for the sample(s) identified on the attached chain-of-custody received in our laboratory on 02/01/07. The project was identifed as your project "Town of Phillipstown / #40605 – Task 5 ".

The analyses were conducted utilizing appropriate EPA, Standard Methods, and ASTM methods as detailed in the data summary tables .

All samples were received in proper condition meeting the NELAC acceptance requirements for environmental samples except those indicated under the Notes section of this report.

All the analyses met the method and laboratory standard operating procedure requirements except as indicated under the Notes section of this report, or as indicated by any data flags, the meaning of which is explained in the attachment to this report, if applicable.

The results of the analyses, which are all reported on an as-received basis unless otherwise noted, are summarized in the following table(s).

Analysis Results

Client Sample ID			3175 Rt 9		1123 Rt 9	
York Sample ID			07020080-01		07020080-02	
Matrix			WATER		WATER	
Parameter	Method	Units	Results	MDL	Results	MDL
Volatiles, 524.2 List+MTBE	EPA 524.2	ug/L	---	---	---	---
1,1,1,2-Tetrachloroethane			Not detected	0.5	Not detected	0.5
1,1,1-Trichloroethane			Not detected	0.5	Not detected	0.5
1,1,2,2-Tetrachloroethane			Not detected	0.5	Not detected	0.5
1,1,2-Trichloroethane			Not detected	0.5	Not detected	0.5
1,1-Dichloroethane			Not detected	0.5	Not detected	0.5
1,1-Dichloroethylene			Not detected	0.5	Not detected	0.5
1,1-Dichloropropylene			Not detected	0.5	Not detected	0.5
1,2,3-Trichlorobenzene			Not detected	0.5	Not detected	0.5
1,2,3-Trichloropropane			Not detected	0.5	Not detected	0.5
1,2,3-Trimethylbenzene			Not detected	0.5	Not detected	0.5
1,2,4-Trichlorobenzene			Not detected	0.5	Not detected	0.5
1,2,4-Trimethylbenzene			Not detected	0.5	Not detected	0.5
1,2-Dibromo-3-chloropropane			Not detected	0.5	Not detected	0.5
1,2-Dibromoethane			Not detected	0.5	Not detected	0.5
1,2-Dichlorobenzene			Not detected	0.5	Not detected	0.5
1,2-Dichloroethane			Not detected	0.5	Not detected	0.5

YORK

Client Sample ID			3175 Rt 9		1123 Rt 9	
York Sample ID			07020080-01		07020080-02	
Matrix			WATER		WATER	
Parameter	Method	Units	Results	MDL	Results	MDL
1,2-Dichloroethylene (Total)			Not detected	0.5	Not detected	0.5
1,2-Dichloropropane			Not detected	0.5	Not detected	0.5
1,3,5-Trimethylbenzene			Not detected	0.5	Not detected	0.5
1,3-Dichlorobenzene			Not detected	0.5	Not detected	0.5
1,3-Dichloropropane			Not detected	0.5	Not detected	0.5
1,3-Dichloropropylene			Not detected	0.5	Not detected	0.5
1,4-Dichlorobenzene			Not detected	0.5	Not detected	0.5
2,2-Dichloropropane			Not detected	0.5	Not detected	0.5
2-Chlorotoluene			Not detected	0.5	Not detected	0.5
4-Chlorotoluene			Not detected	0.5	Not detected	0.5
Benzene			Not detected	0.5	Not detected	0.5
Bromobenzene			Not detected	0.5	Not detected	0.5
Bromochloromethane			Not detected	0.5	Not detected	0.5
Bromodichloromethane			23	0.5	Not detected	0.5
Bromoform			Not detected	0.5	Not detected	0.5
Bromomethane			Not detected	0.5	Not detected	0.5
Carbon tetrachloride			Not detected	0.5	Not detected	0.5
Chlorobenzene			Not detected	0.5	Not detected	0.5
Chloroethane			Not detected	0.5	Not detected	0.5
Chloroform			68	0.5	0.9	0.5
Chloromethane			Not detected	0.5	Not detected	0.5
Dibromochloromethane			Not detected	0.5	Not detected	0.5
Dibromomethane			Not detected	0.5	Not detected	0.5
Dichlorodifluoromethane			Not detected	0.5	Not detected	0.5
Ethylbenzene			Not detected	0.5	Not detected	0.5
Hexachlorobutadiene			Not detected	0.5	Not detected	0.5
Isopropylbenzene			Not detected	0.5	Not detected	0.5
Methyl tert-butyl ether (MTBE)			Not detected	0.5	Not detected	0.5
Methylene chloride			Not detected	0.5	Not detected	0.5
Naphthanlene			Not detected	0.5	Not detected	0.5
n-Butylbenzene			Not detected	0.5	Not detected	0.5
n-Propylbenzene			Not detected	0.5	Not detected	0.5
o-Xylene			Not detected	0.5	Not detected	0.5
p- & m-Xylenes			Not detected	0.5	Not detected	0.5
p-Isopropyltoluene			Not detected	0.5	Not detected	0.5
sec-Butylbenzene			Not detected	0.5	Not detected	0.5
Styrene			Not detected	0.5	Not detected	0.5
tert-Butylbenzene			Not detected	0.5	Not detected	0.5
Tetrachloroethylene			Not detected	0.5	Not detected	0.5
Toluene			Not detected	0.5	Not detected	0.5
Trichloroethylene			Not detected	0.5	Not detected	0.5
Trichlorofluoromethane			Not detected	0.5	Not detected	0.5
Vinyl chloride			Not detected	0.5	Not detected	0.5
Chloride	EPA 300	mg/L	399	10.0	52.4	5.0
Sodium	EPA 200.7	mg/L	368	0.20	4.18	0.20
Nitrate	EPA 300	mg/L	1.68	0.05	1.00	0.05

YORK

Client Sample ID			52 Lane Gate Rd		3556 Rt 9	
York Sample ID			07020080-03		07020080-04	
Matrix			WATER		WATER	
Parameter	Method	Units	Results	MDL	Results	MDL
Volatiles, 524.2 List+MTBE	EPA 524.2	ug/L	---	---	---	---
1,1,1,2-Tetrachloroethane			Not detected	0.5	Not detected	0.5
1,1,1-Trichloroethane			Not detected	0.5	Not detected	0.5
1,1,2,2-Tetrachloroethane			Not detected	0.5	Not detected	0.5
1,1,2-Trichloroethane			Not detected	0.5	Not detected	0.5
1,1-Dichloroethane			Not detected	0.5	Not detected	0.5
1,1-Dichloroethylene			Not detected	0.5	Not detected	0.5
1,1-Dichloropropylene			Not detected	0.5	Not detected	0.5
1,2,3-Trichlorobenzene			Not detected	0.5	Not detected	0.5
1,2,3-Trichloropropane			Not detected	0.5	Not detected	0.5
1,2,3-Trimethylbenzene			Not detected	0.5	Not detected	0.5
1,2,4-Trichlorobenzene			Not detected	0.5	Not detected	0.5
1,2,4-Trimethylbenzene			Not detected	0.5	Not detected	0.5
1,2-Dibromo-3-chloropropane			Not detected	0.5	Not detected	0.5
1,2-Dibromoethane			Not detected	0.5	Not detected	0.5
1,2-Dichlorobenzene			Not detected	0.5	Not detected	0.5
1,2-Dichloroethane			Not detected	0.5	Not detected	0.5
1,2-Dichloroethylene (Total)			Not detected	0.5	Not detected	0.5
1,2-Dichloropropane			Not detected	0.5	Not detected	0.5
1,3,5-Trimethylbenzene			Not detected	0.5	Not detected	0.5
1,3-Dichlorobenzene			Not detected	0.5	Not detected	0.5
1,3-Dichloropropane			Not detected	0.5	Not detected	0.5
1,3-Dichloropropylene			Not detected	0.5	Not detected	0.5
1,4-Dichlorobenzene			Not detected	0.5	Not detected	0.5
2,2-Dichloropropane			Not detected	0.5	Not detected	0.5
2-Chlorotoluene			Not detected	0.5	Not detected	0.5
4-Chlorotoluene			Not detected	0.5	Not detected	0.5
Benzene			Not detected	0.5	Not detected	0.5
Bromobenzene			Not detected	0.5	Not detected	0.5
Bromochloromethane			Not detected	0.5	Not detected	0.5
Bromodichloromethane			Not detected	0.5	Not detected	0.5
Bromoform			Not detected	0.5	Not detected	0.5
Bromomethane			Not detected	0.5	Not detected	0.5
Carbon tetrachloride			Not detected	0.5	Not detected	0.5
Chlorobenzene			Not detected	0.5	Not detected	0.5
Chloroethane			Not detected	0.5	Not detected	0.5
Chloroform			Not detected	0.5	Not detected	0.5
Chloromethane			Not detected	0.5	Not detected	0.5
Dibromochloromethane			Not detected	0.5	Not detected	0.5
Dibromomethane			Not detected	0.5	Not detected	0.5
Dichlorodifluoromethane			Not detected	0.5	Not detected	0.5
Ethylbenzene			Not detected	0.5	Not detected	0.5
Hexachlorobutadiene			Not detected	0.5	Not detected	0.5
Isopropylbenzene			Not detected	0.5	Not detected	0.5
Methyl tert-butyl ether (MTBE)			Not detected	0.5	Not detected	0.5
Methylene chloride			Not detected	0.5	Not detected	0.5
Naphthanlene			Not detected	0.5	Not detected	0.5
n-Butylbenzene			Not detected	0.5	Not detected	0.5
n-Propylbenzene			Not detected	0.5	Not detected	0.5

YORK

Client Sample ID			52 Lane Gate Rd		3556 Rt 9	
York Sample ID			07020080-03		07020080-04	
Matrix			WATER		WATER	
Parameter	Method	Units	Results	MDL	Results	MDL
o-Xylene			Not detected	0.5	Not detected	0.5
p- & m-Xylenes			Not detected	0.5	Not detected	0.5
p-Isopropyltoluene			Not detected	0.5	Not detected	0.5
sec-Butylbenzene			Not detected	0.5	Not detected	0.5
Styrene			Not detected	0.5	Not detected	0.5
tert-Butylbenzene			Not detected	0.5	Not detected	0.5
Tetrachloroethylene			Not detected	0.5	Not detected	0.5
Toluene			Not detected	0.5	Not detected	0.5
Trichloroethylene			Not detected	0.5	Not detected	0.5
Trichlorofluoromethane			Not detected	0.5	Not detected	0.5
Vinyl chloride			Not detected	0.5	Not detected	0.5
Chloride	EPA 300	mg/L	---	---	70.5	5.0
Sodium	EPA 200.7	mg/L	---	---	37.6	0.20
Nitrate	EPA 300	mg/L	---	---	1.78	0.05

Units Key: For Waters/Liquids: mg/L = ppm ; ug/L = ppb For Soils/Solids: mg/kg = ppm ; ug/kg = ppb

Notes for York Project No. 07020080

1. The MDL (Minimum Detectable Limit) reported is adjusted for any dilution necessary due to the levels of target and/or non-target analytes and matrix interference. This MDL is the REPORTING LIMIT and is based upon the lowest standard utilized for calibration where applicable.
2. Samples are retained for a period of thirty days after submittal of report, unless other arrangements are made.
3. York's liability for the above data is limited to the dollar value paid to York for the referenced project.
4. This report shall not be reproduced without the written approval of York Analytical Laboratories, Inc.
5. All samples were received in proper condition for analysis with proper documentation.
6. All analyses conducted met method or Laboratory SOP requirements.
7. It is noted that no analyses reported herein were subcontracted to another laboratory.

Approved By: [signature]
Robert Q. Bradley
Managing Director

Date: 2/12/2007

YORK

YORK
ANALYTICAL LABORATORIES, INC.
120 RESEARCH DRIVE STRATFORD, CT 06615
(203) 325-1371 FAX (203) 357-0166

Field Chain-of-Custody Record

P.O.# E07913 PER C. MONIAN 2/9/07 07020080

Company Name	Report To:	Invoice To:	Project ID/No.	
Town of Philipstown	Chazen Russo/Urbanmead	CHAZEN	#40605 Task 5 PER CATHERINE MONIAN 2/5/07	Samples Collected By (Signature) ___ Name (Printed) ___

Sample No.	Location/ID	Date Sampled	Sample Matrix Water	Soil	Air	OTHER	ANALYSES REQUESTED	Container Description(s)
04	3175 Rt 9	1/31/07	X				Hydrocarbons EPA METHOD 524 plus MTBE	Glass Vial
05	3175 Rt 9	1/31/07	X				↓ — ↓	
06	3175 rt 9	1/31	X				Sodium, Chloride, Nitrate	Plastic
07+08	1123 rt 9		X				Hydrocarbons EPA METHOD 524 plus MTBE	Glass Vial
09	1123 rt 9		X				Sodium, chloride, Nitrate	Plastic
010+011	52 Lane Gate Rd		X				Hydrocarbons EPA METHOD 524 + MTBE	Glass Vial
012+013	3556 Rt 9		X				Hydrocarbons 524 + MTBE	Glass
014	3556 Rt 9		X				Sodium, Chloride, Nitrate	plastic
			X					
		↓						

Chain-of-Custody Record

Bottles Relinquished from Lab by	Date/Time	Sample Relinquished by	Date/Time	Sample Received by	Date/Time
		[signature]	2/1/07 9:50 AM	Wayne	2/1 950

Bottles Received in Field by	Date/Time	Sample Relinquished by	Date/Time	Sample Received in LAB by	Date/Time
				[signature]	2-1-07 /1545

Comments/Special Instructions 3.8 °C

Turn-Around Time
___Standard ___RUSH(define)________

Eastern Laboratory Services Ltd
quality ■ accuracy ■ reliability

ENVIRONMENTAL
2566 Pennsylvania Ave.
Sayre, PA 18840
Phone (570) 888-0169
FAX (570) 888-0717

Certificate of Analysis

Chazen Companies 21 Fox Street Poughkeepsie NY, 12601	Project: Town Of Phillipstown Project No: 40605 Task5 Project Manager: Monian	**Reported:** 02/08/07 17:40

#01-523 East Mtn. N.
7B01056-01 (Drinking Water)

Date Sampled: 01/31/07 08:30
Date Received: 02/01/07 16:28

Analyte	Result	MCL	Units	Prepared	Analyzed	Method	Analyst	Notes
Radiologicals by EPA/SM/ASTM Methods								ACCU*
Radon	2100	4000	pCi/L	02/05/07 00:00	02/05/07 00:00	SM 7500 Rn-B		

ACCU* = Analysis performed by NYS DOH #11769, PA DEP #19-36

#02-#8 Horton Rd.
7B01056-02 (Drinking Water)

Date Sampled: 01/31/07 12:30
Date Received: 02/01/07 16:28

Analyte	Result	MCL	Units	Prepared	Analyzed	Method	Analyst	Notes
Radiologicals by EPA/SM/ASTM Methods								ACCU*
Radon	380	4000	pCi/L	02/05/07 00:00	02/05/07 00:00	SM 7500 Rn-B		

ACCU* = Analysis performed by NYS DOH #11769, PA DEP #19-36

#03-1892 Rt. 9
7B01056-03 (Drinking Water)

Date Sampled: 01/31/07 13:55
Date Received: 02/01/07 16:28

Analyte	Result	MCL	Units	Prepared	Analyzed	Method	Analyst	Notes
Radiologicals by EPA/SM/ASTM Methods								ACCU*
Radon	1700	4000	pCi/L	02/05/07 00:00	02/05/07 00:00	SM 7500 Rn-B		

ACCU* = Analysis performed by NYS DOH #11769, PA DEP #19-36

Eastern Laboratory Services, Ltd.

Irene Chu

Reviewed by Irene Chu, Laboratory Director

The results in this report apply to the samples, as received by the laboratory, analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

PA 08380 NY 11216

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quality ■ accuracy ■ reliability

ENVIRONMENTAL
2566 Pennsylvania Ave.
Sayre, PA 18840
Phone (570) 888-0169
FAX (570) 888-0717

Certificate of Analysis

Chazen Companies	Project: Town Of Phillipstown	
21 Fox Street	Project No: 40605 Task5	**Reported:**
Poughkeepsie NY, 12601	Project Manager: Monian	02/08/07 17:40

#01-523 East Mtn. N.
7B01056-01 (Drinking Water)

Date Sampled: 01/31/07 08:30
Date Received: 02/01/07 16:28

Analyte	Result	MCL	Units	Prepared	Analyzed	Method	Analyst	Notes
Radiologicals by EPA/SM/ASTM Methods								ACCU*
Radon	2100	4000	pCi/L	02/05/07 00:00	02/05/07 00:00	SM 7500 Rn-B		

ACCU* = Analysis performed by NYS DOH #11769, PA DEP #19-36

#02-#8 Horton Rd.
7B01056-02 (Drinking Water)

Date Sampled: 01/31/07 12:30
Date Received: 02/01/07 16:28

Analyte	Result	MCL	Units	Prepared	Analyzed	Method	Analyst	Notes
Radiologicals by EPA/SM/ASTM Methods								ACCU*
Radon	380	4000	pCi/L	02/05/07 00:00	02/05/07 00:00	SM 7500 Rn-B		

ACCU* = Analysis performed by NYS DOH #11769, PA DEP #19-36

#03-1892 Rt. 9
7B01056-03 (Drinking Water)

Date Sampled: 01/31/07 13:55
Date Received: 02/01/07 16:28

Analyte	Result	MCL	Units	Prepared	Analyzed	Method	Analyst	Notes
Radiologicals by EPA/SM/ASTM Methods								ACCU*
Radon	1700	4000	pCi/L	02/05/07 00:00	02/05/07 00:00	SM 7500 Rn-B		

ACCU* = Analysis performed by NYS DOH #11769, PA DEP #19-36

Eastern Laboratory Services, Ltd.

Irene Chu

Reviewed by Irene Chu, Laboratory Director

The results in this report apply to the samples, as received by the laboratory, analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

PA 08380 NY 11216

Appendix B

Wastewater Evaluation

Wastewater Management Options Review

Town of Philipstown, New York

June 2007

Prepared for:

Town of Philipstown
238 Main Street
P.O. Box 155
Cold Spring, New York 10516

Prepared by:

The Dutchess County Office
The Chazen Companies
21 Fox Street
Poughkeepsie, New York 12601
(845) 454-3980

Dutchess County *(845) 454-3980* | *Orange County* *(845) 567-1133* | *Capital District* *(518) 273-0055* | *North Country* *(518) 812-0513*

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Goals of Study

This study of wastewater alternatives has been commissioned with the primary objective of outlining approaches which the Town may use to protect public health by ensuring clean potable water. As the Town is considering revisions to its zoning, this study was commissioned to ensure the viability of proposed changes. Much of the town relies on local groundwater wells that may be impacted by nearby wastewater (i.e. septic) systems that discharge to the aquifer via subsurface leach fields. Upgrading or replacing these systems is one way to provide wellhead and water resource protection. This report discussed options for improving individual systems, and for implementing community wastewater systems. It is recommended that the Town give attention to various options for small community systems in order to further its goals of fostering compact development and smart growth.

Recommended Sewer System Approaches

This report discusses numerous technical approaches to localized wastewater treatment. The most economically feasible alternative for most individual, residential lots is a standard septic and leach field system. Zoning and aquifer recharge rates should be aligned so that rural areas with anticipated use of individual wells and septic systems will not begin experiencing water quality defects when areas reach build-out.

Where closer development patterns are desired, enhanced individual systems can provide higher levels of treatment in septic-sized tanks. The higher cost and more complex operation and management burdens can be justified only under such mitigating circumstances. Enhanced septic systems and other pre-engineered "package" systems are generally most practical for small community applications. For systems using collection systems (rather than use only of enhanced individual systems), particularly high density (< ½ acre lots) and smaller street frontage distances are needed to make interconnections economical. Hamlet zoning should encourage the size criteria in anticipated hamlet centers. New York State regulations do not allow any wastewater system to be shared between multiple owners without some common ownership entity such as a public sewer district, or a private Sewage Works Transportation Corporation. Therefore, extremely interconnected small systems (e.g. less than approximately 50 connections) are seldom financially practical.

A smaller quantity of larger wastewater plants is almost always less expensive and easier to manage than a large number of smaller plants. Traditional, gravity-assisted collection systems and full-capacity wastewater treatment plants have stood the test of time as reliable and cost-effective treatment options. Where feasible, community sewage treatments systems should be located down-hill from the served population so gravity sewers can be used to the greatest extent possible. Although pumped systems are common and feasible, gravity systems often have the most assured long-term reliability. The primary argument in favor of decentralized small plants and enhanced individual treatment systems arises only where there is a great distance between desired service areas, making interconnection of serviced areas impractical.

When areas of existing septic are upgraded to a community system, the Town should consider whether to install small-diameter variable-grade sewers. These systems involve leaving the existing septic tanks in-place for primary solids removal, and then installing a community sewer to a community treatment plant. Keeping solids out of the sewer greatly decreases sewer installation costs by allowing the collection system to use smaller pipe, replacing manholes with simple cleanouts (for gravity sewers), and allowing gravity sewers to fluctuate in grade and follow the topography, which eliminates deep excavations. An additional benefit of this approach is that the primary treatment provided by the septic tanks can reduce the loading on the community system by one third, allowing for a smaller treatment system. One drawback is that the sewer district often then assumes ownership and maintenance responsibility for the septic tanks, depending on how the sewer district is formed.

It should be noted that an alternate method of ensuring a clean potable water supply is to install community water systems in areas where groundwater is impacted by wastewater discharges. Often, installing central water supplies is a more economically feasible alternative than providing wastewater system upgrades. This is a responsible alternative as long as the local septic systems are not also significantly compromising environmental quality in streams, ponds or aquatic ecosystem areas. In these circumstances, installing a local public water system will not mitigate the other environmental impacts, and upgraded wastewater facilities should be considered ahead of providing public water, to both improve well water quality and surface water quality.

Recommended Management Approaches

New, large, private developments should be encouraged to facilitate central sewerage. The town should encourage development within existing or planned sewer districts so that the Town maintains control over critical Town infrastructure. In situations where public commissioning of new wastewater infrastructure for these projects is infeasible, the developer can perform initial construction and operation of the systems under a private Sewage Works Transportation Corporation to ease any immediate financial burden on the Town. Transportation Corporation law allows the encompassing municipality to assume ownership of private wastewater systems at a future date, or requires the private system to receive sewage from surrounding properties under a variety of agreements. Therefore short-term private ownership can be transformed into future public benefit to satisfy the Town's future needs

Redevelopment and in-fill of existing areas with a variety of land owners is best addressed with a publicly-owner infrastructure. Although much of the town appears to be sparsely developed, it is recognized that central water supply or sewage treatment will not be needed in all areas in the future due to extensive restrictions from topography, wetlands, ridgelines, and other factors. Instead, future development will more likely focus on select intersection areas and existing hamlet areas. In such areas of in-fill and multiple ownership, most community wastewater approaches should involve public funding and ownership.

Traditional sewer districts seek to serve all or most residences and properties within their boundaries. It is worth noting that New York State town law also allows for the creation of sewer districts that include both central sewered areas, as well as implementing a septic tank management plan for outlying properties without interconnecting sewer infrastructure. Such an approach would be beneficial to Philipstown in that the creation of more central sewer districts would create an incentive for higher density development in targeted areas. In addition, it would create a formal mechanism for maintaining and upgrading specific individual septic systems in areas that may be compromising ground water or well quality. This may be the best approach for the Town to achieve dual goals of targeted development and groundwater protection. One such system that has been successfully implemented in the mid-Hudson Valley is Woodstock, New York. Such hybrid districts may be a good fit for Philipstown, and should be investigated further.

Recommended Future Actions

The Town already has a master plan, and information has been included in this aquifer report regarding topography and location of potable wells. The Town should commission a more formal study to create a sewer district concept plan. This plan would use the above-mentioned resources (and others) to determine which areas have the greatest need for water supply or wastewater improvements for purposes of wellhead protection and ecological protection. The concept plan would identify water supply areas, or sewer types and sewerage routing for specific areas, as well as the locations and types of well field or community treatment systems.

1.0 BACKGROUND

In response to Town planning initiatives and concerns about groundwater availability, the Town Board of the Town of Philipstown formed an ad-hoc groundwater working group early in 2006 to identify specific groundwater planning inputs necessary to advance the Town's comprehensive plan and zoning processes. This group met with a hydro-geologist from The Chazen Companies to review existing and necessary additional groundwater information. The group then recommended specific additional investigation tasks to the Town Board. A review of the applicability in Philipstown of onsite and decentralized wastewater treatment and disposal systems was one of the tasks under the groundwater study authorized for investigation by the Town Board, and is the subject of this report.

Section 2.0 of this report describes both standard wastewater characteristics and the treatment guidance or standards applicable for discharge of treated wastewater.

Sections 3.0 and 4.0 describe typical methods for managing the Solids and Fluid components of Wastewater.

Section 5.0 discusses traditional collection systems that could be associated with either a Centralized or decentralized treatment facility.

Section 6.0 and 7.0 review treatment and management options for the Town of Philipstown

Section 8.0 describes specific regulatory concerns as they apply to implementation

Section 9.0 makes recommendations for implementation of these types of systems within the Town.

1.1 Location

Philipstown lies along the Hudson River, extends from Westchester to Dutchess Counties, and is bounded on the east by the Towns of Putnam Valley and Kent. Philipstown has an area of approximately 49 square miles and includes the incorporated villages of Nelsonville and Cold Spring. Based on census data, the 2000 population of Philipstown including Nelsonville and Cold Spring was approximately 9,400.

1.2 Developed Areas

The population in Philipstown is widely distributed, but population and commercial concentrations exist along the NYS Route 9 corridor, and in population centers in Garrison, the villages of Nelsonville and Cold Spring, and in the Continental Village community near Cortlandt Lake.

1.3 Water Quality Issues

The Town of Philipstown does not lie within the New York City Watershed and is not regulated by the City of New York. The restrictions imposed by the 1997 Watershed Rules and Regulations do not apply, unlike the remaining majority of Putnam County. The only area within the town that has a traditional wastewater collection and treatment system of any significance lies within the Village of Cold Spring.

Some of the more densely settled areas within the Town of Philipstown and the Village of Nelsonville reportedly experience difficulty with closely-spaced septic systems. In addition to instances of surface-water septage seeps, groundwater sampling would likely show elevated concentrations of wastewater constituents in such areas. Figure 7 in the main body of this report identifies areas where existing parcel sizes are smaller than recommended to ensure adequate dilution of septic system wastes. Options for the proper treatment and disposal of wastewater is a subject of concern both for existing areas with reported or suspected wastewater management difficulties, and for future proposed development areas recommended in the Town's Comprehensive Plan. The use of traditional septic systems too close together represents a potentially-significant source of non-point aquifer contamination. Contaminants from septic systems include compounds with existing regulatory standards such as nitrate or e-coli, which are primary sources of concern at this time, and more recently recognized constituents such as caffeine, pharmaceuticals, and hormone residues, for which no standards yet exist.

The coincident use of septic systems and groundwater wells requires an evolving management strategy to ensure continued sustainable use of both, or requires infrastructure modifications, either by introducing enhanced treatment capabilities to the existing septic systems or by investing in either decentralized or traditional gravity/central treatment wastewater systems.

2.0 WASTEWATER CHARACTERISTICS

Wastewater is characterized in terms of physical, chemical, and biological composition. Many of these characteristics are interrelated and many of these characteristics can be treated or removed prior to discharge. In order to provide effective treatment of wastewater, flowrates and composition must be understood. These two parameters aid in the selection, sizing and location of critical treatment processes, all of which should be addressed to protect public health and the environment.

2.1 Wastewater Flowrates

NYSDEC or NYSDOH design factors are generally used to estimate flowrates for existing projects or predict flows from proposed projects. Generally, NYSDEC protocols used to calculate such estimates are fairly conservative, and wastewater systems designed to meet such demand end up being conservatively sized.

Actual flow rates are normally substantially lower than design flows due to conservative design requirements, but vary considerably according to the use patterns of the actual occupants. A properly-designed system design should be sufficiently flexible to accommodate peak flows but must also be able to function efficiently while handling the lowest anticipated flow rates between use periods, i.e. while residents are at work.

2.2 Wastewater Composition

The composition of raw wastewater in most residential communities will normally meet the design characteristics of medium-strength domestic wastewater, typical of residential communities with light to moderate commercial activity (*Wastewater Engineering*, Metcalf & Eddy, Third Edition, 1991). This composition is independent of population, although smaller populations are prone to more drastic fluctuations from the average if single users deviate sharply from the norm. Within towns, commercial sources such as restaurants will generate higher strength wastewater.

Typical wastewater constituent concentrations in medium-strength domestic wastewater are listed below (Metcalf & Eddy, 3rd ed, 1991):

Table 2.2 Typical Composition of untreated domestic wastewater:

Contaminants	Unit	Concentration		
		Weak	Medium	Strong
Solids, total (TS)	mg/L	350	720	1200
Dissolved, total (TDS)	mg/L	250	500	850
Fixed	mg/L	145	300	525
Volatile	mg/L	105	200	325
Suspended Solids (SS)	mg/L	100	220	350
Fixed	mg/L	20	55	75
Volatile	mg/L	80	165	275
Settleable Solids	mL/L	5	10	20
Biochemical oxygen demand, mg/L: 5-day, 20°C (BOD_5, 20°C)	Mg/L	110	220	400
Total Organic Carbon (TOC)	Mg/L	80	160	290
Chemical Oxygen Demand (COD)	Mg/L	250	500	1000
Nitrogen (total as N)	mg/L	20	40	85
Organic	mg/L	8	15	35
Free ammonia	mg/L	12	25	50
Nitrites	mg/L	0	0	0
Nitrates	mg/L	0	0	0
Phosphorus (total as P)	mg/L	4	8	15
Organic	mg/L	1	3	5
Inorganic	mg/L	3	5	10
Chlorides[a]	Mg/L	30	50	100
Sulfate[a]	Mg/L	20	30	50
Alkalinity (as $CaCO_3$)	Mg/L	50	100	200
Grease	Mg/L	50	100	150
Total Coliform[b]	#/100 mL	10^6 - 10^7	10^7 – 10^8	10^7 - 10^9
Volatile organic compounds (VOCs)	micro g/L	<100	100 - 400	>400

a Values should be increased by amount present in domestic water supply.

b See Table 3 – 18 for typical values for other microorganisms.

Note: 1.8(°C) + 32 = °F.

Many of these constituents are at least partially mitigated by passage through traditional septic systems. Most are not, however, treated fully to drinking water quality standards at the point where effluent reaches the water table. For example, Metcalf & Eddy (1991) reports nitrate concentrations up to 40 mg/l at a depth of 3 feet below the bottom of absorption trenches, which is often near the depth of the underlying receiving water table. The decomposition record for many household chemicals in septic systems is not well understood, but a widely-recognized presence of such chemicals in streams where the surrounding watershed is populated by septic systems suggests these chemicals move from the homes, through the septic systems and aquifers, to the streams, with only partial decomposition, if any. The presence of pharmaceutical residues and other household chemicals also in streams receiving outfalls from conventional wastewater treatment plants suggests such facilities are similarly unable to fully treat such chemicals.

When these and other wastewater constituents are passed through septic systems, they may impact groundwater quality, as addressed below (Chazen, 2004):

Contaminant	**Behavior**	**Management Approach**
Nitrogen compounds	Nitrogen compounds normally convert to <u>nitrate</u> in aquifers. Nitrate does not decay in groundwater or bond to soils, so it travels long distances if released to septic systems. The drinking water standard for nitrate in water is 10 mg/l.	Density of installed systems must be managed to ensure that adequate recharge is provided to dilute nitrate in the aquifer to meet drinking water standards.
Phosphorous compounds	When released to septic systems, phosphate bonds to receiving soils. However, as soil bonding capacity is sequentially expended, the phosphorous front migrates outward from the septic system, eventually developing a long plume. No drinking water standard exists for phosphorous.	Where environmental impacts of phosphorous loading to receiving wetlands and streams exceed surface water standards, wastewater treatment is necessary.
Bacteria & viruses	When released to septic systems, bacteria and viruses generally attenuate within 100 feet from subsurface disposal systems; however, they can sometimes travel much further.	Adequate separation is needed between septic systems and wells or receiving surface water bodies. Where feasible, wells should not be installed immediately down gradient from septic systems or closer than several hundred feet from streams or lakes.

Household chemicals, pharmaceuticals, caffeine, personal care chemicals, detergent byproducts.	Caffeine, detergent byproducts, and other chemicals have been found in streams near septic system, confirming that these migrate through the aquifers to the streams. They do not appear to decompose easily. No drinking water standards yet exist.	Research universities, USGS, and Federal health studies are presently evaluating these contaminants, their potential impacts, and appropriate responses.

2.3 Treated Effluent Limits

To discharge wastewater either to the subsurface or to surface waters, State and Federal regulations require some level of treatment. Such treatment standards aid in the protection of water supplies and water resources in accordance with the Clean Water Act.

2.3.1 Subsurface Disposal

Soil is frequently used to provide treatment and disposal of wastewater. Soil has a large capacity to retain, transform and recycle many of the pollutants found in wastewater. As the wastewater percolates through the soil to the groundwater, physical, chemical, and biological processes occur to provide a level of treatment that is consistent and reliable. Subsurface applications include slow rate, rapid infiltration and overland flow. Most subsurface applications utilize a septic tank and subsurface wastewater infiltration systems.

In general, septic tank effluent is discharged to a Subsurface Wastewater Infiltration System (SWIS), also known as a Subsurface Disposal System (SDS) or absorption field. Such systems provide some treatment of the wastewater by introducing it to a media (soil) for bacteriological growth and degradation for further breakdown of wastewater constituents. The effluent from a septic tank varies naturally depending upon the influent wastewater composition and conditions which exist in the tank.

The quality of wastewater released to the environment from septic systems has been the subject of various studies, but is generally understood to contain nitrate, phosphorous, bacterial and viral concentrations exceeding groundwater standards, as well as various chemical and pharmaceutical residues. The effectiveness of treatment or dilution of these constituents within the aquifer has been broadly assumed, and has contributed to the lack of regulatory attention to this matter, but is increasingly coming under broad scrutiny and the sustainable use of septic systems is being increasingly understood to be related to the density of installed septic systems and sometimes the aquifer media. Some wastewater constituent concentrations do break down in aquifers; others are only diluted within the aquifer and are only remediated upon eventual discharge and exposure to biological processes in active surface waters, or remain in increasingly dilute concentrations even in the receiving surface waters.

2.3.2 Surface Disposal

In order to discharge to the surface waters of the United States, a State Pollution Discharge Elimination System (SPDES) Permit will need to be issued. The SPDES Permit is an implementation of the National Pollution Discharge Elimination System (NPDES) administered under sections 318, 402, and 405 the Clean Water Act. The goal of these permits is to set discharge limits in order to maintain the quality of the receiving water bodies. Final values are calculated by NYSDEC from a waste assimilative capacity (WAC) analysis based on receiving stream characteristics and anticipated effluent flow rates.

NYSDEC stream classifications are as follows (listed from most stringent to least stringent): AA or A is assigned to waters used as a source of drinking water; B indicates a best usage for swimming and other contact recreation, but not for drinking water; C is for waters supporting fisheries and suitable for non-contact activities; and D is the lowest classification. Additional sub-classifications exist for streams essential to trout or trout spawning ("t" and "ts" respectively) that also affect effluent quality requirements.

A fifth category of water body independent of Classes A, B, C, or D is the Intermittent Stream. These are streams that cease to flow during certain seasons, or where discharged effluent constitutes a large portion of the total stream flow. Regardless of a stream's A, B, C, or D classification, its intermittent status automatically triggers a requirement to apply Intermittent Stream Effluent Limits (ISEL) for discharged wastewater. Because there is no natural stream flow into which the effluent can assimilate, no analysis is required to establish ISEL values specific to a project. Rather, ISEL values are predetermined and are commonly 5 mg/L Biological Oxygen Demand (BOD), 10 mg/L Total Suspended Soils (TSS), 2.2 mg/L ammonia (winter), 1.5 mg/L ammonia (summer), and 0.1 ml/L settleable solids. Disinfection is always required for surface water discharges. There are no current wastewater treatment standards for emerging pharmaceutical or hormone wastewater constituents.

2.4 Description of Biological Treatment Theory

Untreated wastewater contains many organic compounds that can be broken down by natural bacteria found in the environment. Such bacteria consume oxygen when degrading these compounds, creating a biochemical oxygen demand (BOD). High BOD in groundwater or surface water depletes dissolved oxygen needed by ecologically balanced systems and so can destroy aquatic life. Most of the treatment options reviewed in this summary utilize aerobic biological processes to treat the wastewater by relying on or providing oxygen to stimulate the growth of bacteria which consume wastewater constituents, thus reducing the remaining BOD in the treated effluent. This is the most efficient and most common method for treating domestic wastewater solids in the United States, whether in septic systems, conventional wastewater treatment plants, or in a host of alternative treatment systems.

If a stream receiving discharge from a wastewater treatment plant has special dissolved oxygen (DO) concerns, the treated effluent may be subjected to "post-aeration" prior to discharge, in which air is injected to further boost oxygen levels and reduce a "DO sag" that can occur in the receiving stream segment near the point of discharge.

With proper design, an added benefit to aerobic biological processes is the oxidation of ammonia found in all domestic wastewater to nitrate in a process called nitrification. Nitrate, is not however fully benign, and there is a drinking water standard for nitrate of 10 mg/l, and elevated nitrate discharges to surface water environments can cause algal blooms and other eutrophic responses to nutrient overload. Some wastewater treatment processes address this concern by also performing de-nitrification, in which nitrate is converted to gaseous nitrogen and oxygen.

Although the treatment alternatives found in subsequent sections of this report are all biologically similar, they differ greatly from one another in the mechanical methods used to manage the biological processes. These differences are reviewed in the following sections.

3.0 SEPTIC SYSTEMS

Septic systems are typically used on individual parcels by implementing individual septic tanks and individual absorption fields. Sometimes septic tanks are used individually or communally as a treatment system for small communities with a common subsurface disposal system.

3.1 Septic Tank

The use of a septic tank is the most commonly used wastewater pretreatment or solids management unit used in onsite applications. The primary purpose of the septic tank in a traditional septic system is to allow separation by means of settling and flotation of solids and oil/grease in the waste stream. A septic tank can be used by itself or in combination with other treatment processes to capture and begin treatment of raw wastewater prior to release either on-site for discharge and assimilation into the groundwater aquifer, or for further treatment.

The septic tank provides primary treatment and provides a reservoir by which 60 to 80 percent of settleable solids and floating debris are removed. (Baumann et al., 1978). The separation of the incoming wastewater fluids from the settled out or floating solids allows retained organic solids to be partially digested, reducing sludge volumes, and the effluent to flow to absorption fields. “Septic tanks are generally used as the first or only pretreatment step in nearly all onsite systems regardless of wastewater flow rate or strength.” (Onsite Wastewater Treatment Systems Manual, USEPA 2002)

Table 3.1 Septic Tank Effluent

Parameter	Septic Tank Effluent Quality
BOD	46-156 mg/L
Total Organic Carbon	31-68 mg/L
Total Kjeldahl Nitrogen	19-53 mg/L
NO3-N	0.01-0.16 mg/L
Total Phosphorous	7.2-17 mg/L
Total Dissolved Solids	354-610 mg/L
Chlorides	37-110 mg/L
Fecal Coliform	3.6-5.4 log # per 100mL

Adapted from Anderson et al., 1994 as presented in USEPA 2002.

If properly maintained a septic system and associated subsurface disposal system can serve a property or properties for many, although seldom and unlimited number of, years. This option serves communities without utilizing town owned facilities or infrastructure. The maintenance of these facilities can be limited to pumping out the solids in the tank once every three to five years, if designed and operated properly. These systems require little or no maintenance over their life and operate very efficiently. Septic tanks require only a modest space for installation, although regulations do require specific setbacks.

It should be noted that commercial facilities, restaurants, etc. require a Grease Trap in accordance with NYSDOH and NYSDEC regulations. In some instances the grease trap may be as large as the septic tank if not larger. This is a significant design consideration when evaluating the use of on-site or off-site and shall not be dismissed. The selection of a grease trap is not included as it is assumed that this is required for these facilities.

3.2 Common Fluid Treatment and Subsurface Disposal

This section describes many treatment systems utilized for subsurface disposal of septic tank effluent.

Systems reviewed in Sections 3.2.1 through 3.2.6 are currently permitted under the New York State Department of Health Appendix 75a Regulations. Many of these are presented in the 1996 DOH Individual Residential Wastewater Treatment Systems Design Handbook. These systems treat and dispose of effluent for subsurface disposal.

Due to the limitations of biological treatment systems, each of the options below may in some cases require pretreatment (see Section 4.1) or post-treatment filtration steps to reduce nutrient or other constituent concentrations to acceptable discharge concentrations. Additionally, each alternative below may in some cases require effluent disinfection by either chlorination/dechlorination or by ultraviolet radiation prior to discharge.

3.2.1 Subsurface Wastewater Infiltration Systems (SWIS)

Subsurface Wastewater Infiltration Systems (SWIS) are most commonly referred to as absorption fields or absorption beds. These are the most common and traditional approaches for managing domestic wastewater discharges from individual homes. Community absorption fields are also relatively common. Absorption fields contribute additional biological treatment beyond that provided by the septic tank in a typical Septic System.

In general all effluent from a Septic Tank or an Aerobic Tank for an individual system under 1000 gallons per day is discharged to a subsurface treatment system. Larger systems function similarly but required permits from NYSDEC in addition to those provided by NYSDOH or its local health units. These systems are the most commonly used systems for dispersal of onsite wastewater. Infiltrative areas are located in permeable, natural soil, or imported fill material so wastewater can infiltrate and percolate through the underlying soil to the ground water. As the wastewater infiltrates and percolates through the soil, it is treated through a variety of physical, chemical, and biochemical processes and reactions.

Table 3.2.1 – Examples of Soil Infiltration System Performance

Parameter	**Applied concentration in milligrams per liter**	**Percent removal**
BOD_5	130-150	90-98
Total Nitrogen	45-55	10-40
Total phosphorous	8-12	85-95*
Fecal coliforms	na[a]	99-99.99

[a] Fecal Coliforms are typically measured in other units, e.g. colony forming units per 100 milliliters
* Long-term phosphorous treatment diminishes as sorption capacity is spent.
Source: Adapted from USEPA, 1992

3.2.2 Shallow Absorption Trenches

These systems are typically utilized where the usable soil onsite is a minimum of 2-feet but less than 4-feet to an unusable soil or other boundary condition. These trenches generally include a distributor pipe installed in an aggregate consisting of washed or cleaned stone. The stone provides a surface for bacteria to grow in order to further breakdown the biological components of the septic tank effluent. These trenches are installed closer to the surface and provides the effluent treatment required. These systems typically are installed where the well draining soils exist closer to the surface as opposed to deeper in the soil strata onsite.

3.2.3 Deep Absorption Trench Systems

These systems are the same as a shallow system although just installed deeper in the soil strata. These types of systems are utilized where the usable soil that exists on-site is overlain by three to five feet of impermeable soil. The unusable soil is excavated and a typical absorption trench is placed two feet into the usable soil.

These systems are more costly to install than shallower trenches however the level of treatment is typically the same.

3.2.4 Pressurized Absorption Beds

These systems operate the same as an absorption trench; however several laterals are installed in a single excavation rather than just one. These are typically used where the site has long narrow areas where the slope is less than 8%. These systems require a pressure distribution system. Unlike a Shallow or Deep absorption trench where gravity can be utilized, these systems require a pressure distribution system to push the water out onto the gravel media.

3.2.5 Graveless (gravel-free) System

Graveless systems have been widely used and are referred to as graveless or gravel free because the seepage lines are installed without any surrounding gravel media. They take many forms, including open-bottom chambers, fabric wrapped pipe and synthetic materials. These systems typically utilize large diameter corrugated pipe surrounded by a fabric. The surface area of the fabric provides the surface for the effluent from the Septic tank to penetrate the surface. An advantage to this type of system is it can be installed on steep slopes, with small digging equipment or hand trenches. The soil infiltration rate is typically 1 to 45 minutes per inch. No imported soil is required as the excavated soils are used to backfill the pipe. These can be used where a conventional gravity system would not be possible as the fabric disperses the water along the length of a 10-24-inch diameter pipe. The claim that these types of systems can reduce the size of the system can be attributed to the gravel not getting clogged. These systems typically allow more effluent to pass to the soil, however the amount of reduction or treatment of contaminants is reduced as the time of transmission in the aeration zone in the soil is shorter. A disadvantage in this type of system is that the effluent from the system can clog the fabric resulting in a 50% reduction of absorption area which will limit the amount of BOD, pathogens and other contaminants treated for. An advantage to these types of systems is they do not require large heavy machinery and can be installed with a smaller crew.

3.2.6 Cut and Fill

These systems are utilized where an unusable soil (one with a percolation rate greater than 60 minutes) is underlain by a usable soil (one with a percolation rate less than 60-minutes). These systems remove the poor draining soils and a typical absorption trench is installed on the usable soils. The soil placed above the system must be imported as it is required to have a percolation rate faster than 60-minutes.

3.2.7 Seepage Pits

These are also called leaching pits, or leaching pools. These systems are a covered tank with open joints or perforated lining where the effluent from the septic tank is absorbed into the soil. These systems dispose of wastewater effluent from a septic tank by utilizing a large tank or covered pit. This is the oldest form of disposing of grey water. Today, these are typically utilized where the "black water" or solids constituents have been removed or do not exist in the wastewater stream. These are typically utilized to reduce the liquid load on the overall onsite system. Larger capacity cesspools serving more than 25 persons are no longer allowed by USEPA.

3.3 Alternative Fluid Treatment and Subsurface Disposal

Alternative systems are more complex than the systems described in Section 3.2 above and must be designed on a site-by-site basis with drawings submitted by a design professional for approval by the Health Department, although 75a does allow them. Typically these systems are not utilized except in particularly complex sites or when retrofitting an existing traditional site with significant site constraints.

3.3.1 Raised System

A raised system typically consists of a conventional absorption trench system constructed in stabilized imported permeable fill material with acceptable permeability placed above the natural soils onsite. These systems are typically utilized where there exists at least one-foot of original soil with acceptable percolation rates above any boundary or other site constraint. These are typically the same costs as an absorption trench; however the difference in cost is the imported fill to provide the required separation distances.

3.3.2 Mounds

A mound is similar to a raised system in that it is elevated above the natural soil surface in suitable fill material; it is a variation of a raised bed which does not require a stabilization period. These are typically utilized where there exists insufficient depth to bedrock or groundwater. The fill material is utilized to treat the wastewater due to the close proximity to groundwater or other site constraints. A mound system is a pressurized system. These typically involve complex designs and are costly to build.

3.3.3 Intermittent Sand Filtration

Intermittent sand filtration comprises of intermittent application of wastewater on a single pass sand filter or other gravel media and the effluent is collected with an under drain system and delivered to a subsurface absorption facility. These are utilized where pre-treatment is needed prior to discharge. These should only be used on large lots and they are not intended for use where the surface is impermeable due to the absorption system would exhibit continuous weeping due to groundwater seepage.

3.3.4 Evapo-Transpiration Systems

These systems are typically not utilized in this area of the country as the evaporation rate does not exceed the precipitation rate. These systems depend on the upward movement of moisture through the soil, surface vegetation and the air as opposed to absorption into the soil medium even though some movement through the soil is accounted for. These systems require large areas in order to provide the surface area required for evaporation-transpiration.

3.4 Other Fluid Treatment and Subsurface Disposal

The systems described below are rarely utilized or permitted, but can be appropriate in areas where additional treatment of septic tank effluent is required to meet specific discharge requirements or because of unique site constraints which would require additional levels of treatment prior to discharge.

3.4.1 Bottom Draining Peat Filter

These systems are typically utilized after a septic tank as a pretreatment of wastewater in order to provide a cleaner effluent for discharge to a subsurface disposal system. A pressurized system is typically required to deliver the effluent to the disposal fields. A peat filter pre-treats septic tank effluent by filtering it through a two-foot-thick layer of sphagnum peat before sending it to the soil treatment system. Peat is partially decomposed organic material with a high water-holding capacity, large surface area, and chemical properties that make it very effective in treating wastewater. Unsterilized peat is also home to a number of different microorganisms, including bacteria, fungi, and tiny plants. All of these characteristics make peat a reactive and effective filter. Peat filters typically remove high concentrations of nutrients (nitrogen and phosphorus) and produced a high-quality effluent. Because peat filters produce cleaner wastewater, they are useful for sites with "disturbed" (compacted, cut, or filled) soil and for environmentally sensitive areas such as shore land areas in shallow bedrock areas, aquifer recharge areas, and wellhead protection areas. Due to the pretreatment, there typically is an allowance for a smaller footprint subsurface disposal field which allows a more compact system to be installed on a parcel which may not be large enough for a traditional system. These offer almost complete nitrification of wastewater and offer 96% removal of 5-day BOD.

Because of the high organic content of peat, the filter media must be periodically replaced as the media breaks down over time or reach saturation of critical wastewater constituents. This means physically removing the layer of peat when it has begun to decompose. Life expectancy of the peat media in a filter is estimated to be ten to fifteen years. The system should be designed to make it easy to remove and replace the peat. Module peat filters are easier to maintain than lined peat filters because they are open to the surface.

Costs for a peat filter typically are between $5,000 and $10,000, for the tank, pump and initial peat installation, for an individual home. Costs for replacing the peat after approximately 7 years is around $4,000. Overall operations and maintenance of these types of systems is around $200-$500 a year including inspections and removing degraded peat.

3.4.2 Geotextile Filter

A geotextile filter utilizes fixed film treatment technology. The wastewater is introduced to the geotextile where biological floc can grow and accumulate and treat the wastewater. The geotextile is used to provide a compact biomass. These are typically installed after the Septic tank to provide further treatment prior to discharge to a subsurface disposal system. These can reduce the concentrations BOD and TSS upwards of 90%, and have reached an effluent concentration of between 5 and 10 mg/L if operated correctly. The tank provided for the filter would need to be cleaned out periodically as the biomass would slough off much like a RBC or trickling filter (see Section 5.0). In addition the geotextile may become clogged if not operated correctly. This system much like a Trickling filter works best when operated intermittently.

Maintenance of this type of system is comparable to a peat filter where the tank will need to be cleaned out periodically and the geotextile may need to be replaced as it may rip or tear.

3.4.3 Recirculating Sand Filter

A Recirculating filter utilized sand, gravel, or other media to provide additional treatment of settled wastewater or septic tank effluent. These typically consist of a tank or chamber where the media is placed with a recycle to return treated effluent either to the beginning of the system or to discharge. These are fixed film systems and are typically aerobic. The more the water is cycled through the system the “cleaner” the effluent becomes, although the more recycle the bigger the system needs to be in order to handle the additional capacity. Typically recycle rates are between 3:1 and 5:1. These systems typically require little maintenance and offer greater removals of nitrogen from wastewater. Maintenance is removing vegetation from the surface of the filters, as well as removing accumulated solids if any pass the settling tank.

The media filters the coarser solids from the wastewater stream as it percolated through the media. In addition depending upon the media; sand or other, will allow additional removal by utilizing a specific media. The recirculating sand or other media filter will also offer pretreatment prior to discharge to a subsurface infiltration system and further reduce TSS and BOD. Recirculating sand filters are used where there exists boundaries, i.e. high groundwater or shallow bedrock, which would limit the effective treatment of the wastewater prior to assimilation. The wastewater is typically introduced to a sand filter where the site is smaller, or there is a requirement for additional nitrogen removals.

Costs for a recirculating sand filter are mainly driven by the media costs, but include the recirculating tank; pumps and controls tend to vary between $8,000 and $11,000 depending on the site requirements. The use of an alternative media can significantly alter the cost.

Maintenance of the filter for monthly inspections and electrical costs for the pump as well as management costs are typically between $250 and $350 per year.

3.4.4 Bottomless Sand Filter

Bottomless sand filters are similar to intermittent sand filters and recirculating sand filters, but remain single pass sand filters. These are typically non-buried open beds with direct discharge to soil, meaning there is no bottom liner and this allows the water to percolate directly into the ground. These are typically thin film systems and wastewater is typically applied to a 2-3 foot deep sand bed by a pipe network and manifolds. These are typically utilized where a conventional system cannot be employed due to site constraints. Wastewater is applied in a time dosed manner and is allowed to percolate through the sand. The sand in these systems requires the same maintenance as stated above with respect to raking the surface of accumulated solids and the removal of vegetation.

3.4.5 Drip Irrigation

Drip irrigation systems are a type of shallow lower pressure trenches and utilize shallow trenches either at or near the surface for the placement of small diameter pipe to distribute pretreated wastewater to the upper levels of the soil utilizing the soils potential for treatment. These systems incorporate shallow low pressure pipe networks to evenly distribute the wastewater over the surface utilizing a dose/rest cycle. The effluent from the pretreatment unit (typically a septic tank) needs to be filtered so as to not clog the distribution network. Subsurface drip irrigation systems are often used for sites with adverse conditions such as: soils which are unsuitable for conventional absorption systems; insufficient depth to a restrictive horizon or ground water; and steep slopes. Since initial capital costs tend to be relatively high as compared with other disposal options, and regular maintenance of these systems is necessary to ensure their proper functioning, they may be most cost-effective where more than one home is served by the same drip irrigation system. These types of systems are better suited for arid climates and are probably not so prevalent in the northeast although can be employed if there existed sufficient site constraints.

The costs to construct this type of system are typically around $15,000 for the initial construction. The operations and maintenance costs for this type of system is typically around $50 per month.

3.4.6 Non-Waterborne (zero or minimal discharge)

These are typically utilized in areas of the state where running water is not available or to scarce and there is a need or desire to conserve water. The treatment of grey water (water from sinks, showers and other facilities not containing solids waste) may utilize these systems. These systems consist of Composters, Chemical and Recirculating Toilets, incinerating toilets and grey water systems.

- *Composters:* accept waste into a chamber where composting occur. These are typically only utilized in accordance with the manufacturer's recommendations and must be National Sanitary Foundation (NSF) Standard 41 or equivalent. Only composting systems with a five year warranty are to be installed.

- *Chemical and Recirculating Toilets:* accept waste into a chamber which contains chemicals for disinfection and to control odors. The chemicals are typically reused after the wastes are separated. These do not completely disinfect the waste and as a result further treatment is required. The wastes from this system are not to be discharged to surface waters or the ground surface.

- *Incinerating Toilets:* accept waste into a chamber where the wastes are burned. These units typically have limited capacity and require a fuel source, typically gas or electric. The incinerated remains must be removed periodically.

- *Greywater systems:* These systems typically do not have solids in them. Mainly these systems only receive waters from showers, laundry facilities, sinks and other sources that do not carry wastewater solids. These systems must treat the greywater streams to the criteria required for discharge to either subsurface systems or surface waters.

- *Holding Tank*. The use of a holding tank would only be able to be used as a temporary measure, i.e. during the construction of a treatment system. These are generally not an acceptable means of treating wastewater.

4.0 ENHANCED COLLECTION AND TREATMENT SYSTEMS

This section addresses more complex wastewater collection and/or treatment systems. Some can be added to septic systems to improve or enhance the quality of discharged subsurface effluent. Most are more commonly used as part of small to mid-size (decentralized) or mid-size to large size (conventional) wastewater treatment districts.

4.1 Primary Treatment

Primary treatment is used as part of most decentralized and all conventional wastewater treatment systems. Primary treatment can include pre-treatment by grinding, screening, or settling of large solids before they reach subsequent primary treatment processes. Primary treatment typically involves simple mechanical processes such as screening (usually by bar screens) and grit removal, (through constant velocity channels) to remove wastewater solids.

Solids are commonly misinterpreted to consist only of dry matter, whereas in fact wastewater solids remain extremely high in moisture and are better thought of as a wet sludge than as a solid.

4.1.1 Screening

The use of a screen is highly effective in removing solids which are bigger than the screen which may enter the system. The screen provides a physical barrier in which larger solids get captured.

4.1.2 Comminutor (a.k.a. Grinder)

The use of a Comminutor is used in order to grind large particles in order to provide greater surface area for further treatment. This also breaks up larger particles for a more effective removal from the wastewater stream, or to prevent clogging or blocking of downstream components. A comminutor is generally used to protect subsequent treatment equipment. A Comminutor does not remove solids from the stream, it only makes them smaller. The smaller solids would need to be removed downstream. A complication created by grinders is that the reduced solids size may inhibit downstream primary settling.

4.1.3 Primary Settling Tank

The use of a Primary Settling tank is one of the most common, widely-used wastewater treatment processes currently utilized today for solids. From individual systems to much larger systems this tank provides separation of larger heavier particles from the wastewater effluent. The most common primary settling tank for smaller systems is a septic tank.

It can be desirable in smaller treatment systems to include a dosing tank or a flow equalization tank as part of, or up-front of the treatments described below to receive short-lived flow surges and allow them to be later pumped to the treatment system at a reduced steady rate.

4.2 Secondary Treatment

The following technologies treat fluid wastewater. Most include a measure of primary treatment (addressed previously) but then otherwise commonly treat the combined waste stream. Most discharge to a surface water outfall; however, downsized units can be used to enhance performance of individual septic systems, resulting in either clarified fluid flow to the septic discharge fields, or even to reduce nutrient transmission to the septic discharge fields.

These technologies primarily rely on fostered growth of bacteria suspended in and mixed with sludge and fluid wastewater slurry. Bacteria and biosolids generated by the digestive activity of the bacteria and any other residual solids are removed from the treated wastewater for off-site disposal as sludge, and the clarified effluent is discharged.

Sometimes a share of the concentrated sludge is recycled back to the treatment process in order to maintain a highly active bacteria concentration in the treatment area, also called *mixed liquor suspended solids* (MLSS). Because the sludge is biologically active, many of these suspended technologies are also referred to as *activated sludge* systems.

4.2.1 Conventional Activated Sludge

Activated sludge processes typically contain an aeration basin in which air is mixed with the wastewater, which transfers oxygen to the wastewater and creates an environment ideal for growing suspended bacteria. The treated wastewater leaves the aeration basin by flowing to a gravity clarifier, from which the clarified effluent overflows to discharge. The settled sludge is either recycled back to the aeration tank or removed for disposal, depending on the needs of the system.

These systems are referred to as *continuous flow suspended growth aeration systems (CFSGAS)* because they continuously receive wastewater into an aeration tank, where the mixing, aeration, and biological activity occur. Wastewater flows into the top of this tank at one end and overflow the top of the tank at the other end. As a result, the retention time of wastewater in the tank is determined by the influent flow rate. High flow rates result in less treatment time, and low flow rates can lead to excessive aeration and mixing times until new influent water displaces the old water from the tank.

In addition to an aeration tank, each CFSGAS system requires a flow equalization tank and a clarifier tank. The equalization tank receives short-lived influent flow surges so that wastewater can be pumped to the aeration tank at a constant flow to increase treatment efficiency. The clarifier tank receives treated water from the aeration tank so that solids (activated sludge) can settle out via gravity and clarified water can be discharged.

4.2.2 Sequencing Batch Reactor

Sequencing Batch Reactors (SBR) combine all the steps of the activated sludge process into a single tank that treats wastewater in discrete batches. Raw wastewater flows into the SBR tank, where it is equalized for flow, treated, clarified, and discharged. A typical SBR system consists of two alternating reactor tanks, so that while one is engaged in the treatment process (and is shut off to incoming wastewater); the second is receiving wastewater from the sewer system.

Because SBR is a batch process with adjustable treatment duration, this technology is ideal for situations with variable wastewater loadings and flows. Additionally, the fact that an SBR system does not normally require an equalization basin helps reduce the footprint of the WWTP for situations where land is at a premium. One perceived disadvantage of an SBR system, however, is its mechanical and controls complexity.

4.2.3 Membrane Bioreactor

Like conventional activated sludge plants, a Membrane Bioreactor (MBR) plant provides primary clarification or screening, followed by an aeration tank for treating the wastewater. However, the clarification process of an MBR plant is unique in that it uses high-performance filtration membranes inserted directly into the mixed liquor to extract clear water, rather than using a conventional gravity clarifier. The advantages are:

- Better clarification. Filtration is superior to a gravity clarifier for removal of activated sludge, TSS, poorly-settled solids, and flocculated phosphorus.

- Higher MLSS. Conventional activated sludge plants operate at a low MLSS (approximately 3,000 mg/l) because to operate higher would send more solids to the clarifier, compromising effluent quality. Because the MBR membranes can easily remove solids better than a gravity clarifier, MBR systems can operate at a much higher MLSS (>10,000 mg/l), allowing the same level of treatment to be attained in a smaller tank volume.

- Smaller footprint. The MBR filter membranes eliminate the need for large gravity clarifiers, and the high MLSS allows a smaller aeration tank than a conventional system. The end result is a treatment plant on a much smaller footprint than a conventional activated sludge system.

4.2.4 Rotating Biological Contactor

A rotating biological contactor (RBC) is one type of a group of technologies called *fixed film,* which is separate and distinct from the *suspended growth* alternatives discussed above. Fixed film technologies foster the growth of bacteria that are attached as a fixed film to a solid surface (or media) instead of suspended in the wastewater. Because the bacteria are not mixed into the wastewater, the wastewater must be exposed to the media surface (and hence to the fixed film) for treatment to occur. As the fixed film grows too thick to remain attached to the media, it sloughs off into the wastewater and must be removed as sludge. This sludge is disposed of and is not recycled back to the process. It is good practice for fixed film systems to be preceded by flow equalization and some form of primary treatment such as a primary settling tank or influent screen.

In an RBC system, the media is a large cylindrical wheel several feet in diameter that rotates slowly. The RBC is positioned above the wastewater tank, so that the bottom portion is submerged in wastewater. As the RBC rotates, the portion of the fixed film that is submerged treats the wastewater, and then is rotated out of the water for the fixed film bacteria to receive oxygen from the air.

RBCs have the advantages of being easy to operate, and being less sensitive to shock loading and influent strength variability. However, they can require expensive periodic maintenance of the media and rotating mechanisms. They also are very susceptible to cold because of the air exposure required of the media and its fixed film. Susceptibility to cold, however, would not apply if they are enclosed in a building.

Additional disadvantages are specific to seasonal communities. An RBC cannot be restarted quickly after a low-flow period during which the fixed film is depleted. Because the fixed film bacteria must grow on the media surface, the system can't be easily seeded from an existing source, as can a suspended biological system. This initial and restart growth period may require several weeks. An additional disadvantage of fixed film systems is that they often require larger secondary settling tanks than activated sludge systems.

4.2.5 Trickling Filter

A trickling filter is *fixed film* technology in which a tower or tank is packed with a media, which historically has been rock but is now more commonly plastic. Wastewater from primary treatment (equalization and clarification) is applied to the top of the packing media, where it flows down through the media by gravity to an under drain below. The organic content of the wastewater stimulates the growth of a microbial film on the media surface, which then consumes that organic content, reducing its concentration and reducing the wastewater BOD. Oxygen is supplied to the microbial film via direct contact of the media with air as the wastewater intermittently trickles past.

Trickling filters are designed in two configurations; low-rate and high-rate. Low-rate trickling filters receive wastewater at either a lower flow rate or lower organic loading per square foot than do high-rate filters. This difference in loading creates advantages and disadvantages in each. A disadvantage common to both low and high rate trickling filters is that they often require larger secondary settling tanks than activated sludge systems.

Low rate systems have the following advantages. They are able to degrade most of the influent BOD as it trickles down through the top 1-3 feet media. The resulting low organic content of the water in the lower media encourages nitrogenous bacteria to degrade any ammonia and create a highly nitrified effluent. This is advantageous when discharge permitting requires low ammonia limits. Disadvantages of low rate systems include thick slime layers on the media that occasionally slough off and require additional clarification, and the aesthetic nuisance of filter flies that thrive on the media surface. The low flow rate creates areas of media that are infrequently flushed with water, allowing larvae and flies to thrive.

High rate systems have the advantage of creating a thinner bio-film, which leads to less-pronounced sloughing events in the filter effluent. Additionally, they have fewer filter flies because the higher flow rate keeps the media flushed with water, preventing flies and larvae from thriving. Disadvantages include poor nitrification of wastewater, leading to higher levels of ammonia in the effluent.

All trickling filters are very susceptible to cold because of the air exposure required of the media and its fixed film. Addition disadvantages are specific to seasonal communities. A trickling filter cannot be restarted quickly after a long low-flow period during which the fixed film is depleted. Because the fixed film bacteria must grow on the media surface, the system can't be easily seeded from an existing source, as can a suspended biological system. This initial and restart growth period may require several weeks.

4.2.6 Plant-based (Vegetative) Treatment Systems

Plant-based systems use plant root zones and their bacteria to remove wastewater BOD and nutrients in a process that replaces or complements the aeration step of an activated sludge system. Plant-based systems still require the same equalization and primary settling/screening steps as all of the treatment options described above. Two primary types of plant-based systems are available; outdoor wetlands and engineered basins. Wetlands systems in cold climates tend to be subsurface flow to prevent freezing, while engineered basins tend to be indoor concrete structures similar to other treatment options. There are very few systems like this in New York that are used to treat wastewater. Consequently, regulatory approval may be more complicated than for the other treatment options described here.

Constructed wetlands use aquatic plants in shallow ponds or channels to treat wastewater by natural microbial, biological, physical, and chemical processes. Although they can be a cost-saving alterative in some applications, the US EPA cautions that the small number of existing constructed wetlands results in limited data availability regarding the design, costs, and operations of wetland treatment systems. In general, the EPA considers regions with inexpensive land available and low availability of experienced WWTP operators as the regions for which a constructed wetland treatment system would be most suitable.

Average design parameters published by the EPA indicate that approximately one (1) square foot of wetland area is required for treatment of one (1) gallon of low to medium strength wastewater per day. This parameter is based on empirical data primarily obtained from existing wetland treatment systems located in Louisiana, Mississippi, and other southern states. Additionally, in cold weather climates, a greater wetland treatment area would be required, due to reduced wetland performance during colder periods. A "rule-of-thumb" for constructed wetlands in cold climates is to increase the wetland treatment area by 25%. Additionally, the total area required, including berms, diversion areas, channels, equipment access, etc. would be 1 ½ times the treatment area.

Engineered Wetlands are not considered a preferred alternative for the Town of Philipstown for the following reasons:

- *Approval Process*: The duration of the approval process may be extended by the unique nature of the process. As of 2005, in the mid-Hudson region, there is currently one operating constructed wetland located in the Town of Lloyd, Ulster County serving a single manufacturing facility. The wetland receives and treats a volume of wastewater less than 1/3 of its design capacity on weekdays, and usually receives no flow on weekends or holidays. Its performance therefore cannot be accurately gauged against its design.

- *Extended Startup Period*: Establishing a constructed wetland may require more than one growing season, and is affected by the season in which planting occurs, the density of the plantings, the type of plants, the type of wetland, and weather conditions. During early phases of plant growth, exposure to wastewater is not recommended. It may take several growing seasons for the wetland to reach an optimal vegetative density.

- *Land Use Requirements*: Using the EPA methodology described above, the minimum land required for constructed wetlands (excluding emergency reconstruction area to address bed failure) is fairly sizeable. Land area complications arise because the varying site topography would require extensive grading, terracing, or retaining walls. Attempting to distribute the wetlands across a site in multiple smaller footprints would somewhat diminish this impact. However, the fencing likely required to limit access to untreated wastewater could create a significant visual impact across the property.

- *Technically Impractical*: Effluent quality requirements in many cases are likely higher than a wetland can produce without additional treatment. At a minimum, constructed wetlands would have to be followed by post-aeration to increase dissolved oxygen level, and by disinfection. Depending on the quality of wetland effluent, addition filtration and ammonia removal may also be required. Adding these engineered processes reduces the appeal of wetlands, and makes a conventional WWTP a more practical choice. Additional mechanical complexity is introduced if the wetlands are distributed across the site, thereby requiring a large piping network and additional pump stations.

4.3 Disinfection and Tertiary

Once wastewater has been subjected to primary and secondary treatment, it has low enough suspended solids, biochemical oxygen demand, and nutrient concentrations for subsurface discharge into the ground. However, effluent discharged to a surface water outfall will require disinfection to deactivate any hazardous micro-organisms. The most common disinfection methods are chlorination and ultraviolet (UV) light. For small systems, chlorination usually consists of injecting a liquid sodium hypochlorite solution (similar to household bleach) into the treated effluent, and providing a 15-minute contact time prior to discharge. Disinfected secondary effluent is suitable for environmental discharge to most sizeable water bodies. Discharge to smaller "intermittent" water bodies may require a higher level of treatment, referred to as "tertiary" treatment. In most cases, this involves modifications to secondary treatment to attain high levels of BOD and nutrient reduction. It also commonly includes addition of an advanced filtration system to remove residual suspended solids from the effluent.

5.0 COLLECTION SYSTEMS

Table 6.1-1 summarizes available options for conveying collected wastewater to a common treatment location. A description of each option is presented below.

5.1 Gravity Sewers

Gravity sewers serving small communities tend to be constructed of 8-inch pipe made of PVC plastic. Each sewer section is a straight pipe with a sufficient downward angle to encourage rapid sewage flow. Changes in direction or slope occur at manholes. Advantages include inexpensive and reliable operation. Disadvantages include difficulties in creating steep enough pipe slopes in areas with flat topography, inability to convey water uphill, and the high expense sometimes incurred when flat terrain requires deep excavation or excavation of rock in order to attain sufficient pipe slope over long distances. Gravity sewers are the most common

5.2 Small Diameter Sewers

These systems utilize local solids removal (usually a septic tank) so that only the liquid component of the wastewater is collected and conveyed to a central treatment plant. Septic effluent flows out of the septic tank by gravity into the sewer, which carries it to the plant. The absence of solids in the sewer allows it to be less than the standard 8-inch minimum diameter. Periodic solids removal must occur at all of the local septic tanks. These are commonly referred to as septic tank effluent gravity or STEG systems. A STEP or septic tank effluent pump systems, are similar except for the fact that flows from septic tanks are pumped to the plant instead of flowing by gravity.

5.3 Low Pressure Sewers

Low pressure sewers are also small diameter (<8 inches), but utilize a grinder pump at each residence to grind the wastewater solids and pump the resulting liquefied stream through a smaller diameter pipe to a treatment area. A disadvantage of low pressure systems is that because they do not drain by gravity, they are full of water during down-time and are prone to freezing if not installed reliably below the frost line. Care must be taken to provide sufficient ground cover to prevent line freezing and bursting in winter. The primary advantages are that these systems operate independent of pipe slope and topography, and can convey water uphill if the general overall pipe trend is downhill. And unlike a STEP system, no large septic tank is required in each yard. A downside when compared to STEP is that pumping high solids wastewater creates more pump and line maintenance problems than pumping clarified septic effluent.

5.4 Vacuum Sewers

With a vacuum sewer system, regional transfer stations create a vacuum on local sewer piping, pulling wastewater from nearby residences. Although less commonly implemented than low pressure sewers, vacuum sewers are cost competitive, easy to maintain, and effective in areas with relatively flat topography. However, they have limited usefulness in areas with varied topography because the vacuum can only lift water within the pipe to a practical limit of 22-24 feet from its starting point. An additional disadvantage is that the large regional vacuum pump equipment is usually located in an above-ground building which would require architectural considerations to mitigate visual impact. An advantage is the tight pipe joints minimize infiltration. When pipe breaks do occur there is little sewage leakage to surrounding soils, and any subsequent loss of vacuum triggers a system alarm. Finally, emergency backup power can be easily incorporated into the system design because sewage flow is created by a small number of regional vacuum stations, rather than by large numbers of individual residential pumps.

Table 5.1-1 summarizes the relative applicability of each wastewater collection alternative based on the advantages and disadvantages discussed above.

Table 5-1: Sewerage Alternatives Matrix

Application	Standard Gravity Sewers	Small Diameter Sewers	Low Pressure Sewers	Vacuum Sewers
Highly variable terrain	2	2	1	3
Rocky soils (able to bury lines shallow)	3	2	2	1
Flat terrain	2	2	1	1
Mechanical complexity	1	1	2	2
Minimize infiltration	2	2	1	2
Minimize groundwater contamination from breaks	2	2	3	1
Dependability	1	2	2	2

Note: "1" ranking indicates above-average applicability, "2" indicates average, and "3" indicates below-average applicability.

6.0 REVIEW OF TREATMENT OPTIONS FOR PHILIPSTOWN

There exist a variety of wastewater treatment options for the Town to consider ensuring proper operations and maintenance of individual, decentralized or centralized treatment facilities. Some may require the Town to be integrally involved in the day to day operations, and some require no action by the Town in order for the system to operate. The options discussed below represent those judged to be most likely considered by private or public system developers in the Town, based on land development patterns and the specific geographic constraints frequently encountered in Philipstown.

6.1 Individual Systems

6.1.1 Traditional Septic Systems

This option involves providing individual treatment systems for each home (usually septic tanks) with subsurface disposal via absorption beds. Use of traditional septic systems is only allowed by NYSDOH Rules and Regulations (10-NYCRR-Part 74.4) in new subdivision with 49 or fewer dwelling units. Hydrogeologic conditions detailed in Chazen's 2006 aquifer report identify minimum sustainable parcel sizes for use of septic systems and individual wells. The minimum parcel sizes are:

- For areas with Hydrologic Soil Group A or A/D: 1.2 acres per system
- For areas with Hydrologic Soil Group B: 1.6 acres per system
- For areas with Hydrologic Soil Group C or C/D: 3.0 acres per system
- For areas with Hydrologic Soil Group D: 5.4 acres per system

Adherence to these minimum average septic system densities protects well water quality and also ensures that groundwater quality remains sufficiently clean to cause no surface water quality defects where aquifers discharge water naturally to lakes, streams or wetlands.

The Town does not need to provide maintenance or management of individual parcel wastewater options.

The septic tank is a cost-effective approach for individual homeowners requiring little knowledge on system operations, maintenance and performance.

The costs associated with installation of a septic tank are relatively low, frequently costing less than $1,500, installed. The total initial construction costs can vary depending on the size of the septic system however for a typical household with an absorption field and Septic tank would have an approximate cost between $2,500 and $9,000 installed

There are specific size requirements for septic tanks based upon the flowrates introduced into the system. In addition, they have separation requirements between wells and septic systems, and between septic systems and water sources, bodies of water, foundations, property lines, or other features. Also, septic tanks do not treat many persistent wastewater constituents and periodic pumping does carry a periodic maintenance cost.

6.1.2 Enhanced Septic Systems

For the purposes of this evaluation an enhanced septic system is described as a septic tank, either containing or followed by a supplemental treatment unit, from which treated wastewater flows to a standard subsurface disposal system. A range of secondary treatment units are on the market today and generally provide on a small scale the treatment functions described in Section 4.2. The only difference is the size of the unit installed, which is much smaller than the system that would be installed in a conventional centralized facility. By including one of these units to enhance treatment capacity of a conventional septic system, the effluent or associated levels of treatment achieved can be similar to those levels experienced at a conventional treatment facility.

Disinfection systems can also be added to individual sites, sometimes including use of chemical disinfection systems, at which point, the level of treatment on an individual site becomes essentially equal to that of a full-service wastewater treatment plant. Such complete treatment is seldom considered since such systems begin to be as complex to maintain and operate as a centralized facility.

A list of some available enhanced treatment systems units, their approximate treatment capacity, their operating principle (Section 4.2) and approximate costs is given below and on Table 6.1.2. The Chazen Companies is not endorsing use of any product:

- Trickling Filter, or BIOCLERE;
- Extended Aeration, or NORWECO;
- Recirculating Sand Filter, or ORENCO;
- Sequencing Batch Reactor, or CHROMOGLASS;
- Membrane Bioreactor, or ZENON.

The disposal system still needs to be designed in accordance with the criteria as specified in Appendix 75A and in accordance with the Putnam County Department of Health Standards, and sized as though it were following a conventional septic tank.

Table 6.1.2 Typical Effluent Values for Domestic Enhanced Treatment Options based on Typical Influent Values

	BOD (mg/L)	TSS (mg/L)	TKN (mg/L)	NO_3-N (mg/L)	P (mg/L)	TDS (mg/L)	Fecal Coliform (per 100)	COSTS
BIOCLERE	8-14	8-16	N/A	--	N/A	N/A	N/A	$9,000
NORWECO	--	--	--	--	--	N/A	--	$3,500-$9,000
ORENCO	< 5	2-15	0-3	3-37	6-8	340-770	2-12.5	$10,000-$15,000
CHROMO-GLASS	5	5-22.5	5	1-17	6-8	N/A	4.5-180	$7000-$9000
ZENON	< 2	< 4.3	5-11	0.2	<0.2	N/A	< 2.2	$10,000-$15,000

Effluent values reported above are provided by vendors and have not been verified by The Chazen Companies. Where values are not shown, vendors did not provide data to The Chazen Companies in time for this publication, or the published data was conflicting.

Enhanced treatment systems are only currently used and permitted by the Putnam County Department of Health to remediate failing septic system sites. In the future, if existing or proposed areas with undersized parcels and site or participant number constraints preventing design of linked treatment systems which to use enhanced systems as a regional management strategy, a maintenance district complete with management taxing and operation verification authority will need to be investigated, properly permitted and developed. There is not present precedent for such a management district.

6.2 Small to Mid-Scale, Decentralized Treatment Systems

Decentralized facilities describe any of a range of treatment arrangements which are not massively centralized. The term is used loosely among practitioners and can include regional use of traditional septic systems or enhanced septic systems, or use of several small sewer districts rather than a single regional system. Other practitioners use the term to describe systems which treat solids and fluids in significantly different locations, such as systems using septic tanks on individual parcels but centralized wastewater treatment.

Common to the nomenclature relating to decentralized wastewater treatment is the idea that wastewater is treated usually in smaller volumes, closer to points of wastewater generation, and more often using subsurface disposal methods because of the smaller wastewater volumes involved.

Advantages of decentralized treatment programs include water retention in local areas rather than large water transfers from local wells to a single surface discharge area. Where groundwater supplies are in short supply, decentralized wastewater treatment systems can retain more water in local watershed areas. Another advantage of decentralized treatment systems can be the economical provision of wastewater treatment for small service areas previously believed to be to small to support the costs, space and infrastructure demands typically associated with a full-scale sewage treatment plant. Finally, the use of small-diameter vacuum or pressure collection lines can allow provision of wastewater treatment in areas with considerable topographic relief and significant shallow bedrock with lower costs than those needed to install gravity-fed, larger-diameter sewage collection systems.

6.2.1 Conveyance System Options

A range of small-scale wastewater treatment systems may be applicable for small hamlet areas or other mixed use centers in Philipstown. The service area and the precise treatment arrangements for such districts would need to be evaluated on a case-by-case basis but might include any of the following:

1. Retained use of existing or new Septic tanks to either retain solids or to work in conjunction with a grinder pump to create waste-stream slurry capable of flowing through a small-diameter collection system. From these decentralized collection areas, fluids, or fluid slurry can be delivered via vacuum lines or pressure lines to a local treatment facility where additional treatment occurs and waste fluids are discharged either to subsurface disposal systems or to a surface discharge. The mechanisms for each of these components have been described elsewhere in this report.

2. A small conventional gravity collection system followed by a package-scale full-service wastewater treatment system.

6.2.2 Treatment Plant Options

It seems unlikely that a large town wide sewage treatment facility will ever be proposed in Philipstown. The largest system currently used, in Cold Spring, currently manages approximately 250,000 gallons per day (Chazen, 2004). Although it is practical to expand the plant to serve other parts of the town, connecting those areas to the existing sewer district would require the construction of extensive inter-connecting sewer lines through undeveloped areas that would not benefit from such infrastructure in the near future. Several smaller sewage treatment facilities are more likely due to the topography as well as in order to provide recharging of the groundwater. Smaller plants, or even decentralized facilities due to current zoning and the topography would be more of a viable option than one regional system. The most cost effective way to build a small community treatment plants is to install a pre-engineered, prefabricated "package" plant. Several manufacturers exist that create package plants. Following this approach substantially reduces project cost over a custom-designed system. A traditional or package plant combines many of the systems described above as described below.

- Primary Treatment generally consists of a screen or other device which removes or breaks down larger solids. Flow equalization is an integral design element. This tank receives the short-duration diurnal high-flows, and then pumps them at a lower steady rate to downstream processes for further treatment. This can allow smaller equipment to be purchased and placed in the plant for a more cost-effective design.

- Secondary treatment by one of the processes identified in Section 4.2 processes remove biochemical oxygen demand, ammonia, and phosphorous from the wastewater. This is utilized for further treatment and removal of common pollutants, usually by a biological process.

- Tertiary treatment is required in some cases. Before clear water reaches the filters, it can be dosed with chemicals to further remove constituents such as phosphorous or dissolved solids. Usually provided for removal of specific pollutants e.g. nitrogen or phosphorous, or specific industrial pollutants. Tertiary filtration effectively removes most fine solids, and will remove a portion of microorganisms in this size range, including Cryptosporidium and Giardia. More advanced membrane filtration (0.1 to 1 micron pore size) may be utilized as well.

- Disinfection will be required to deactivate (kill) remaining microorganisms, including viruses that are too small to be substantially removed by tertiary filtration. The effluent will be disinfected either by ultraviolet light (UV) or by a chemical metering system that adds chlorine to kill the organisms and then removes the chlorine for safe environmental discharge of effluent. Any chlorine addition would be done with liquid sodium hypochlorite (similar to household bleach), and not with hazardous chlorine gas.

- The final processes in the WWTP will be post-aeration to raise the water's dissolved oxygen (DO) before discharge. This is done to help ensure a healthy elevated dissolved oxygen level in the receiving stream. Even if there is no DO requirement in the SPDES permit, discharging effluent with high DO will help maintain the quality of the irrigation ponds.

One advantage of a centralized treatment plant is that the wastewater is collected and treated in one location and includes no treatment activities in other locations. This contributes to an economy of scale cost savings. This also locates all of the operational facilities in one location so that maintenance of effluent and discharge can be closely monitored, thus assisting with assurance that quality is consistent. In addition, the Operations and Maintenance of one centralized facility is streamlined. This potentially offers greater opportunities and provides a greater selection of treatment alternatives.

There are also disadvantages to a centralized treatment facility, one being the investment and maintenance cost in collection systems and, where necessary, pump stations. To limit collection system distances, such facilities are almost always located in or near heavily populated areas and it is costly to connect less densely developed areas. The local community can also object to the facility, the outfall or potential noise, visual attraction and odor issues.

The cost of a centralized plant will be based on the selected technology, required equipment, the approximate size of buildings and structures that would be required to support the process, and major site work necessary for construction, such as excavation, grading, and paving. Generally speaking the total cost of a new plant will be approximately $12 - $15 per gallon for secondary effluent quality, and $15 - $20 per gallon for tertiary effluent quality. This engineering, permitting, site plan approval and construction administration fees contributing to 12% - 20% of the construction cost, depending on the complexity of permitting required and the scope of construction services. Annual operations and maintenance costs will be additional. On a per-household basis this typically means between $350 and $500 per year depending on the size of the district.

The majority of operations costs are the electricity to run the equipment depending upon the treatment chosen. Aeration requirements typically are the majority of electric costs. An effective Operations and Maintenance budget will allow for preventative maintenance as required by the operator. This budget can be set up so that it allows for routine preventative maintenance as called for in the new equipment manuals, as well as an allowance for contingency items.

7.0 REVIEW OF MANAGEMENT OPTIONS FOR PHILIPSTOWN

7.1 Individual Ownership and Management

The simplest management option, from the perspective of the Town, is individual ownership of individually owned septic systems. Where septic systems are the preferred wastewater management technique, the Town should ensure that the density of septic systems (e.g. systems per acre, or parcel sizes) do not exceed the carrying capacity of the receiving aquifer. Sustainable septic system density is addressed it the main body of Chazen's aquifer report. This is the simplest and easiest as it requires little or no Town management. Individual ownership is possible for both residences and commercial entities.

7.2 Transportation Corporations (Private Sewer District)

Under New York law, the only way that several private entities can privately own a common wastewater infrastructure is if there is a single ownership entity; a Sewage Works Transportation Corporation ("transcorp"). The area served by the transcorp is essentially a private sewer district, where the transcorp owns and maintains all infrastructure including sewers and wastewater treatment facilities. Individual property owners pay sewer fees to the transcorp as if to a municipal sewer authority. A transcorp must receive approval to incorporate from the Department of State, but must first receive approval from the municipality which encompasses it. Therefore, no transcorp can be created in Philipstown without the Town's prior approval of its creation and sewer rates. Transportation Corporations have many of the same rights and privileges as a public Sewer District defined below although the Town Board has no operating authority, nor operating responsibility beyond rate approval for operations and maintenance.

Transportation Corporations are a common approach for large private residential and commercial developments, and can own and manage all varieties of wastewater management systems, including decentralized or centralized systems.

7.4 Sewer Districts (Municipal Sewer Improvement Area)

A municipal sewer improvement area, also called sewer district, would need to be created and authorized by the Town. Such a system would be administered by the municipality and would be municipally owned. The Town would have responsibility for operations and maintenance. Typically, the Town would hire a contract operator or employee who is to maintain and operate the sewer improvement area and facilities within the system on behalf of the Town.

Such improvement areas are financially self-sustaining entity whereas the costs to operate and maintain the system wide facilities are shared by the residents in the improvement area. Capital expenditures for improvements or upgrades outside of normal maintenance are usually bonded by the improvement area residents which would be a separate expenditure in the operating budget. Sewer improvement area costs are not borne by the Town tax payers at large except in the unlikely event that a sewer district was designed with the eventual intent to serve the whole town. The costs for the sewer improvement area are born by the area residents and are reviewed and approved by the New York State Comptrollers Office.

Connection and discharge standards and rate structures for the sewer improvement area are would need to be incorporated into the Town Code. The Town Board manages the overall administration, operation and maintenance of the Sewer Improvement area by creating a Sewer District in order for continued operations and maintenance the system facilities.

Traditional sewer districts seek to serve all or most residences and properties within their boundaries. However, New York State also allows for the creation of sewer districts that include both central sewered areas, as well as implementing a septic tank management plan for outlying properties without interconnecting sewer infrastructure. Such an approach would be beneficial to Philipstown, in that the creation of more central sewer districts would create an incentive for higher density development in targeted areas. In addition, it would create a formal mechanism for maintaining and upgrading specific individual septic systems in areas that may be compromising ground water or well quality. This may be the best approach for the Town to achieve dual goals of targeted development and groundwater protection.

8.0 REGULATORY CONCERNS

The Chazen Companies have confirmed that the current Town Code for Philipstown and the Putnam County Department of Health Permitting process may need to be amended depending on the range of wastewater treatment alternatives the Town wishes to allow. There are also other concerns with respect to individual discharge standards as well as a sewer connection section which would describe how individual homeowners could connect to either a centralized or decentralized facility.

Any applicant, whether municipal or private, will need approvals from the Putnam County Department of Health for enhanced individual systems or decentralized systems. PCDOH has indicated that it is currently not acceptable to install and operate non-traditional septic system or decentralized systems for new facilities, although these types of facilities are commonly approved for failing systems. As state regulators observe performance of systems installed in failing settings, and develop means to enforce the routine maintenance of such systems, they may over time become more ready to approve such uses with new construction. NYS DOH is currently reviewing and revising parts of Appendix 75A in ways which may allow a wider use of individual septic systems.

The New York State Department of Environmental Conservation requires SPDES permits for wastewater facilities processing more than 1,000 gallons per day, or those serving more then one parcel or one homeowner, or individual commercial facilities. NYSDEC is currently revising regulations for small-scale sewage treatment facilities in ways which may allow wider use of decentralized sewage treatment systems.

The Town Board will need to approve applications for formation of Transportation Corporations in conjunction with the Department of State, submitted by private entities, and create their own special districts. The Town may also wish to develop municipally operated sewer improvement areas or sewer districts. The Town Board may wish to make modification to the zoning code to facilitate or promote the creation of such sewer improvement areas and special districts in desired locations.

9.0 RECOMMENDATIONS

Many towns are seeking to enhance vitality and economic viability of community centers by encouraging compact central areas, and by preserving open space by lowering density of development in outlying areas. To achieve this, the Town should develop a detailed sewer district plan that focuses on the formation of a municipal sewer district. This approach will allow the Town to more successfully impact the direction and nature of future development, and should be incorporated into the Town's Master Plan. Philipstown's mixture of hamlets and low density areas suggests that the best management approach is a sewer district that incorporates small, decentralized community sewers and treatment facilities to serve hamlet areas, and also includes a septic tank management district for outlying areas This septic management district will allow the Town to maintain and upgrade individual septic systems that are impacting critical water wells, and also will provide a regulatory mechanism by which small enhanced septic systems can be shared between private properties.

This study would suggest consideration of the following types of wastewater planning strategies for areas in Philipstown.

9.1 High Density Developed Areas

Such areas may describe northern segments of Route 9, various community cross-roads, and areas near Garrison. These all currently rely on local wells and so need to manage wastewater carefully to neither impact groundwater quality nor export wastewater in ways which would reduce water capacity available to wells.

Such areas generally include parcels one acre and smaller. These areas are good candidates for community (centralized or decentralized) facilities because population density and size can provide required economies of scale. Keeping connection distances below approximately 50 to 80 feet is generally crucial to cost-effectiveness of a conventional collection system. Use of non-gravity collection or variable-grace gravity systems can increase this separation criteria somewhat, can reduce the cost of connecting connections in areas with considerable buried rock, or can allow cost-effective connection of smaller numbers of users in small hamlet areas.

The provision of wastewater treatment facilities in such areas can provide protection of groundwater aquifer so that individual well water quality can be protection, and enhances aquifer quality flowing eventually to nearby streams or lakes. Providing sewage treatment supports sustainable community density by ensuring that groundwater quality is not overtaxed by wastewater loading. The discharge of a community's treated wastewater may be either to surface waters or groundwater, each of which requires treatment to standards regulated by NYSDEC.

Areas with complex topography may find that collection systems other than gravity-flow systems are more cost-effectively installed, leading potentially to on-site solids retention and central fluids management and disposal. Small community areas may find that gravity collection systems with either a surface or subsurface disposal treatment facility will be the most cost-effective wastewater management option.

Annual cost ranges to provide wastewater collection and treatment are likely to fall between $600 and $800 per household, with lower rates possible if development grants or commercial users carry a meaningful share of development or operational costs.

As an alternative, small existing high-density areas experiencing water quality difficulties due to well-septic interferences, may wish to develop wastewater management districts so they can install and manage enhanced treatment units at each existing septic system. Costs for such installations are increasingly viable, annual servicing costs are generally manageable, and groundwater quality withdrawn by wells would be improved. Annual costs for this type of approach could range between $800 and $1,000 per year, covering capital investments in enhanced treatment systems and annual operational costs.

All of these options will require some management participation from the Town, whether to authorize proposed management districts, authorize transportation corporations, or identify, propose and operate municipal sewer improvement areas at any scale.

9.2 Low Density Developed Areas

On-site septic systems are often (and should be) the first option to consider in rural, or low-density development areas. Such systems have the advantages of individual ownership and non-point, low-density waste distribution over large areas, ensuring adequate waste constituent loading in part by dilution.

Based on aquifer analysis completed in the main body of this study, parcels between approximately 1 and 3 acres may not be able to provide adequate dilution of septic system discharges to ensure sustainable groundwater quality. Average density of approximately 3 acres per parcel, or larger, will ensure sustainable use of traditional septic systems in Philipstown.

Installation of individual septic systems requires no management obligation from the Town. Installation of septic systems cost up to $7,000 for traditional systems, with operating costs consisting of periodic septic tank cleaning costing several hundred dollars per event. Installation costs for septic systems on complex sites or requiring advanced treatment will be higher. If a municipal septic management district is implemented, that will allow the installation of more expansive enhanced septic systems that are shared between properties, and therefore more cost effective per residence.

9.3 Small Cluster Developments

NYSDOH Rules and Regulations (10-NYCRR-Part 74.4) require that any new subdivision with 50 or more lots requires a community sewerage system. Therefore, smaller developments can be developed with individual septic systems. However, any development with a "cluster" approach using small lots will likely not be able to sustain individual septic systems. Such developments, which may be viewed favorably by the Town depending on their location, would be possible only with a community system that must be owned/operated by a municipal sewer district or a private sewage works transportation corporation. If Philipstown wishes to encourage such development, and wishes to retain ownership of wastewater infrastructure, it therefore must implement a municipal sewer district.

10.0 REFERENCES

Design Standards for Wastewater Treatment Works for Intermediate Sized Sewerage Facilities, New York State Department of Environmental Conservation, Division of Water; 1988

Recommended Standards for Wastewater Facilities, Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers; Health research Inc Publishers; 1997 Edition

Onsite Wastewater Treatment Systems, United States Environmental Protection Agency, EPA 625/R-00/008

Wastewater Engineering, Treatment, Disposal, and Reuse; Metcalf & Eddy; McGraw-Hill Publishers, Third Edition, 1991

Individual Residential Wastewater Treatment Systems Design Handbook, New York State Department of Health, 1996

Wastewater Treatment/Disposal for Small Communities, United States Environmental Protection Agency, EPA 625/R-92/005

Constructed Wetlands Treatment of Municipal Wastewaters, EPA Manual, EPA/625/R-99/010, September 2000

Appendix C

Model Aquifer Ordinance for Philipstown

The following draft Aquifer Overlay Ordinance for the Town of Amenia, NY was initially drafted under auspices of the Dutchess County Water & Wastewater Authority by the law firm of Rapport Meyers Rodenhausen, LLP and The Chazen Companies, and has been under sequential modification by professional planner Joel Russell. The following text may not be the most recent Amenia draft document.

Amenia's draft ordinance would need to be further modified to reflect aquifers and protection priorities in Philipstown. A conceptual revision to the opening paragraph §121-15(B)(1) follows:

> 1. The Aquifer Overlay (AQO) District encompasses the entire Town of Philipstown and includes two basic types of aquifers: the Clove Creek Aquifer (CCA) area which is extensively developed and fully dependent on groundwater as a source of water supply, and the townwide Regional Aquifer (RA) area where groundwater is also used extensively but the land isless developed than in the CCA or where surface water is used as a source of water supply. The two AQO districts may include future internal aquifer zones, including Buffered Clove Creek Aquifer (BCCA) areas for the service areas of any regionally significant public water supplies developed within the CCA, and Regional Aquifer Wellhead Protection (RAWP) areas where wellhead protection could be provided for any community water system wellfields in the RA.

Other changes to the Amenia model ordinance would be required throughout the model ordinance. Aquifer recharge rates occurring in Philipstown have been inserted in §121-15F.

THE CHAZEN COMPANIES
JUNE 2007

§121-15 AQUIFER OVERLAY DISTRICT (AQO)

A. Legislative Findings, Intent, and Purpose

The Aquifer Overlay AQO District has been created to protect the health and welfare of residents of the Town of Amenia by minimizing the potential for contamination and depletion of the Harlem Valley's aquifer system. The entire Town of Amenia contains an aquifer system that has been divided into four categories described in Subsection B. This aquifer system provides drinking water to public water systems and private wells and also provides groundwater and surface water that is essential to the maintenance of healthy aquatic and terrestrial ecosystems. The Town has determined that a limiting factor on the carrying capacity of the land is its capability to provide water in sufficient quality and quantity so that water use by some users does not adversely affect other users. Another limiting factor on the carrying capacity of the land is its ability to absorb wastewater without adversely affecting the quality or quantity of groundwater and surface water necessary for water supplies and other needs of the natural and human environment. The purpose of these regulations is to protect the Town's groundwater aquifer system, to provide the most protective standards to those areas of the aquifer at greatest risk of contamination, and to manage development so that groundwater supplies are not depleted or degraded.

B. Delineation and Regulatory Effect of District

1. The Aquifer Overlay (AQO) District encompasses the entire Town of Amenia and includes two basic types of aquifers: the Valley Bottom Aquifer, containing significant amounts of groundwater located in areas that are generally more developed, and the Upland Aquifer, containing lesser quantities of groundwater and less development (see definitions in subsection C below). The AQO district consists of three aquifer zones, two in the Valley Bottom Aquifer and one in the Upland Aquifer. These zones are designated as the Priority Valley Bottom Aquifer (PVBA), which is the aquifer area most susceptible to contamination that would affect public water supplies, the Buffered Valley Bottom Aquifer (BVBA), which is less susceptible than the PVBA because it is in an area serviced by public water systems, and the Upland Aquifer (UA) which consists of areas not covered by the Valley Bottom Aquifer zones. These zones are delineated on the Aquifer Overlay District Map. There is also provision in this §121-15 for an Upland Wellhead Protection Area (UWP), which has not been mapped at this time because the Upland Aquifer area does not presently contain any settlements with an intensity of development that would require additional groundwater protection. The UWP category has been established in this Chapter for possible future mapping in the event that more intensive development occurs within the UA zone , resulting in the need to protect public water supply wellheads within this area. The official Aquifer Overlay District Map can be found at the Town offices. A photo-reduction of this map is attached to this chapter for reference purposes. The Aquifer Overlay AQO District map and any amendments to it must be prepared or approved by a hydrogeologist working for the Town.
2. The official Aquifer Overlay District Map shall be used to determine the boundaries of zones within the AQO District. In case of a question or dispute as to the exact location of a boundary on a specific parcel of land, the Town may retain a qualified hydrogeologist at an applicant's expense to make such a determination in the field based upon the criteria in this § 121-15. An applicant may challenge the Town's determination by retaining a qualified hydrogeologist to make such determination independently based upon the criteria in this § 121-15. In the event of such a challenge, the Town's hydrogeologist shall review the report of the applicant's hydrogeologist at the applicant's expense and shall make the final determination as to the location of the specific boundary. Any such boundary delineation shall not, by itself, effect a change in the AQO District Map. The AQO District Map may only be changed by action of the Town Board as provided in Subsection 121-15H.
3. Within the Aquifer Overlay District, all of the underlying land use district rules shall remain in effect except as specifically modified by this § 121-15. In case of a conflict between this §121-15 and the underlying use regulations, the more restrictive shall control. Nothing in this § 121-15 shall be construed to allow uses that are not permitted by the underlying land use district.

C. Definitions
For purposes of this § 121-15, the following definitions shall apply:

Action: A project or physical activity as defined in the SEQR Regulations of the NYS Department of Environmental Conservation, 6NYCRR Part 617 , including all actions subject to SEQR that are covered by this Chapter, as well as subdivision applications and other actions requiring local government approval under SEQR.
Aquifer: A consolidated or unconsolidated geologic formation, group of formations or part of a formation capable of yielding a significant or economically useful amount of groundwater to wells, springs or infiltration galleries.
Aquifer Overlay AQO District Map: The Town's overlay map showing Aquifer Overlay District zones.
Buffered Valley Bottom Aquifer BVBA: Areas delineated as Buffered Valley Bottom Aquifer BVBA on the Aquifer Overlay AQO District Map. As defined or approved by a hydrogeologist working for the Town, BVBA areas consist of regions within the Valley Bottom Aquifer VBA served by community water systems, where the sources of water supply for the community water system and for any other wells would not be substantially threatened by a contaminant release occurring within the BVBA. No portion of the BVBA may lie hydrogeologically upgradient of any wells, including wells used by the community water system.
Community Water System: A public Water System regulated by the New York State Department of Health that serves at least five service connections used by year-round residents or regularly serves at least 25 year-round residents.
Conditionally Exempt Small Quantity Generators: As defined by the Resource Conservation and Recovery Act and amendments thereto, sites generating or storing less than 100 kilograms per month and 1000 kilograms of listed and /or characteristic wastes, respectively, and generating and storing less than 1 kilogram per month and 1 kilogram of acutely hazardous waste, respectively.
Consumption of Water: The net loss of water from a watershed through evaporation and transpiration processes caused by any human activities and associated land uses, other than open space uses, including evaporative losses from septic system leaching lines. The definition of Consumption of Water includes the use of water in diluting wastewater discharges so that groundwater quality at the property line downgradient from the discharge will be 50% or less of the New York State Department of Environmental Conservation's Title 10 Part 703 Groundwater (GA) Water Standards, i.e. the DEC's groundwater contamination standards.
Discharge: Any intentional or unintentional action or omission resulting in the releasing, spilling, leaking, pumping, pouring, emitting, emptying, or dumping of substances or materials into the waters of the State or onto lands from which the discharged substances or materials might flow or drain into said waters, or into waters outside the jurisdiction of the State, when damage may result to the lands, waters, or natural resources within the jurisdiction of the State.
Generator of Hazardous Waste: Any person or site whose act or process produces hazardous waste.
Groundwater: Water contained in interconnected pores and fractures in the saturated zone in an unconfined aquifer or confined aquifer.
Hazardous Substance: Any substance, including any petroleum by-product, which may cause harm to humans or the environment when improperly managed. A complete list of all hazardous substances except for petroleum by-products can be found in 6 NYCRR Part 597.2(b) Tables 1 and 2 and amendments thereto.
Hazardous Waste: See 6 NYCRR Part 371 and amendments thereto for the identification and listing of hazardous wastes.
Herbicide: Any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any weed, and being those substances defined as herbicides pursuant to Environmental Conservation Law § 33-0101, and amendments thereto.
Large Quantity Generator: As defined by the Resource Conservation and Recovery Act and amendments thereto, sites generating more than 1000 kilograms per month of listed and/or characteristic hazardous wastes, or generating or storing more than 1 kilogram per month and 1 kilogram of acutely hazardous waste, respectively.
Major Oil Storage Facilities; Facilities with a storage capacity of 400,000 gallons or more of petroleum.

Natural Recharge: The normal rate at which precipitation enters the subsurface to replenish groundwater in aquifers, without interruption or augmentation by human actions or landscape modifications.

Non-point discharge: Discharges of pollutants not subject to SPDES (State Pollutant Discharge Elimination System) permit requirements.

Pesticide: Any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest, and any substances intended to for use as a plant regulator, defoliant or desiccant, and being those substances defined as pesticides pursuant to Environmental Conservation Law § 33-0101 et seq. and amendments thereto.

Petroleum: Oil or petroleum of any kind and in any form including but not limited to oil, petroleum fuel oil, oil sludge, oil refuse, oil mixed with other waste, crude oil, gasoline and kerosene, as defined in 6 NYCRR Part 597.1(7) and amendments thereto.

Point Source Discharge: Pollutants discharged from a point source as defined in Environmental Conservation Law § 17-0105 and amendments thereto.

Priority Valley Bottom Aquifer PVBA: The area delineated as the Priority Valley Bottom Aquifer PVBA on the Aquifer Overlay AQO District Map. As defined or approved by a hydrogeologist working for the Town, the PVBA consists of all areas within the Valley Bottom Aquifer VBA which are not included in Buffered Valley Bottom Aquifer BVBA areas.

Pollutant: Any material or byproduct determined or suspected to be hazardous to human health or the environment.

Radioactive Material: Any material that emits radiation.

Small Quantity Generator: As defined by the Resource Conservation and Recovery Act and amendments thereto, sites not meeting Conditionally Exempt Small Quantity Generator status but which generate and store less than 1000 kilograms per month and 6000 kilograms of listed and /or characteristic wastes, respectively, and generating and storing less than 1 kilograms per month and 1 kilogram of acutely hazardous waste, respectively.

Solid Waste: Generally refers to all putrescible and non-putrescible materials or substances, except domestic sewage, sewage treated through a publicly owned treatment works, or irrigation return flows, that is discarded or rejected as being spent or otherwise worthless, including but not limited to garbage, refuse, industrial and commercial waste, sludges from air or water treatment facilities, rubbish, tires, ashes, contained gaseous material, incinerator residue, construction and demolition debris and discarded automobiles, as defined in 6 NYCRR Part 360-1.2(a) and amendments thereto.

State Pollutant Discharge Elimination System ("SPDES"): The system established pursuant to Article 17 Title 8 of Environmental Conservation Law for issuance of permits authorizing discharges to the waters of the state of New York.

Upland Aquifer UA: The area delineated as Upland Aquifer UA on the Aquifer Overlay AQO District Map. As defined or approved by a hydrogeologist working for the Town, the UA consists of all areas on the Aquifer Overlay AQO District Map not included in the Valley Bottom Aquifer VBA or in Upland Wellhead Protection UWP areas.

Upland Wellhead Protection UWP areas: Areas delineated or to be delineated in the future as Upland Wellhead Protection UWP areas on the Aquifer Overlay AQO District Map. As defined or approved by a hydrogeologist working for the Town, UWP areas consist of wellhead protection areas for community water system wells not located within the Valley Bottom Aquifer VBA. At a minimum, wellhead protection areas enclose all lands situated within 60-days travel time (seepage velocity) from the community water system's wells, and enclose sufficient land that average annual Natural Recharge in the UWP area matches the average water demand of the community water system.

Valley Bottom Aquifer VBA: The area delineated as the Valley Bottom Aquifer VBA on the Aquifer Overlay AQO District Map. As defined by a hydrogeologist working for the Town, the VBA consists of the following areas:

1. All locations where outcrops of the Stockbridge Formation, as generally defined by New York State Museum Geologic Maps, are present at grade;
2. All locations where the Stockbridge Formation is the first bedrock formation found under unconsolidated soil materials;
3. All overburden soils (sand, gravel, clay, till, etc.) overlying the Stockbridge Formation;

4. All locations which do not overlie the Stockbridge Formation but where moderately to highly permeably overburden soils (K >10^{-5} cm/sec), including stratified silt, sand, and/or gravel are hydraulically connected to, and are substantially contiguous to, the Stockbridge Formation.

The VBA includes the Priority Valley Bottom Aquifer PVBA and Buffered Valley Bottom Aquifer BVBA areas.

Wastewater: Aqueous-carried solid or hazardous waste.

Watershed: That land area that includes the entire drainage area contributing water to the Town water supply and which includes the Aquifer Protection Overlay District.

Water Supply: The groundwater resources of the Town of Amenia, or the groundwater resources used for a particular well or community water system.

Well: Any present or future artificial excavation used as a source of public or private water supply which derives water from the interstices of the rocks or soils which it penetrates including bored wells, drilled wells, driven wells, infiltration galleries, and trenches with perforated piping, but excluding ditches or tunnels, used to convey groundwater to the surface.

D. General Provisions of the Aquifer Overlay District

1. The manufacture, use, storage, or discharge of any products, materials or by-products subject to these regulations, such as wastewater, solid waste, hazardous substances, or any pollutant, must conform to the requirements of these regulations.
2. Usage of Water for proposed actions within the Aquifer Overlay AQO District shall be examined pursuant to SEQRA in accordance with the methodology set forth in Subsections F and G of this § 121-15.
3. In addition to the list of Statewide Type I Actions contained in § 617.4(b) of 6 NYCRR, all proposed actions resulting in discharges exceeding standards provided in 6 NYCRR Part 703.6(e) and amendments thereto (groundwater contamination standards), and all proposed actions where Water Consumption exceeds Natural Recharge, as defined in Subsections F and G herein, shall be designated as Type I Actions under the Implementing Regulations of the State Environmental Quality Review Act (6 NYCRR Part 617), unless the action is listed as a Type II action under such regulations.
4. Installation of any underground fuel tank or tanks, whose combined capacity is less than 1,100 gallons, is prohibited in the Aquifer Overlay AQO District.
5. This Section 121-15 shall not apply to customary agricultural practices conducted in conformity with applicable rules of the New York State Department of Environmental Conservation and the New York State Department of Agriculture and Markets which are in conformance with a whole farm management plan approved by the Dutchess County Soil and Water Conservation District.
6. This Section 121-15 shall not apply to any single-family, two-family, or multi-family residential use of land containing five or fewer dwelling units, or to any home occupation unless such residential use or home occupation includes one of the activities listed in subsection E below.

E. Use and Permit Requirements in the Aquifer Overlay District

In accordance with Article IX of this chapter, the Planning Board shall review and act upon Special Permit applications within the Aquifer Overlay AQO District. If the uses listed below are regulated by any state federal agency, the definitions of such uses and all applicable regulations under state and federal law shall apply.

1. Special Permits within the Priority Valley Bottom Aquifer PVBA and Upland Wellhead Protection UWP areas. The following uses, if permitted in the underlying land use district, shall require the issuance of a Special Permit within the Priority Valley Bottom Aquifer PVBA and the Upland Wellhead Protection UWP areas:
    a. Photo labs;
    b. Auto repair facilities and truck terminals, including engine repair and machine shops;
    c. Furniture stripper/painter, metal works, wood preservers;
    d. Printers and the use of printing presses;
    e. Conditionally Exempt or Small Quantity Generators of Hazardous Waste.

f. Solid waste management facilities not involving burial, including incinerators, composting facilities, liquid storage, regulated medical waste, transfer stations, recyclables handling & recovery facilities, waste tire storage facilities, used oil, C&D processing facilities, each as defined in 6 NYCRR Part 360, and junk or salvage yards in general.

g. Salt storage facilities.

h. Uses where Water Consumption exceeds Natural Recharge.

i. Cemeteries, including pet cemeteries

j. Veterinary hospitals and offices

k Funeral parlors.

l. Storage or disposal of manure, fertilizers, pesticides/herbicides. No special permit shall be required where such storage or disposal is conducted pursuant to a *Whole Farm Management Plan* developed in association with the Dutchess County Soil & Water Conservation District.

2. Special Permits within the Buffered Valley Bottom Aquifer BVBA areas and the Upland Aquifer UA. The following uses, if permitted in the underlying land use district, shall require the issuance of a Special Permit within the Buffered Valley Bottom Aquifer BVBA and Upland Aquifer UA:

a. Gasoline service stations;

b. Major Oil Storage Facilities;

c. Junkyards and automobile cemeteries.

d. Salt storage facilities.

e. Conditionally Exempt, Small Quantity, or Large Quantity Generators of Hazardous Waste.

f. Disposal of any hazardous waste, as defined in 6 NYCRR Part 371, by burial.

g. Land application of septage, sludge, or human excreta, including land application facilities defined in 6 NYCRR Part 360-4.

h. Cemeteries, including pet cemeteries

i. Veterinary hospitals and offices

j. Funeral parlors.

k. Storage or disposal of manure, fertilizers, pesticides/herbicides. No special permit shall be required where such storage or disposal is conducted pursuant to a *Whole Farm Management Plan* developed in association with the Dutchess County Soil & Water Conservation District.

3. Application Requirements: In addition to the Special Permit application requirements set forth in Article IX, applicants proposing actions listed in subsections (1) and (2) above that are located within the Aquifer Overlay AQO District shall identify the following as part of their applications:

a. The source of water to be used;

b. The quantity of water required;

c. Water use minimization measures to be implemented;

d. Water recycling measures to be implemented;

e. Wastewater discharge measures;

f. Grading and/or storm water control measures to enhance on-site recharge of surface water;

g. Point Source or Non-Point Discharges;

h. A complete list of any Hazardous Substances to be used on site along with quantity to be used and stored on site; and

i. A description of Hazardous Substance storage or handling facilities and procedures.

4. Special Conditions for proposed uses within the Priority Valley Bottom Aquifer PVBA and Upland Wellhead Protection UWP areas requiring a Special Permit:

a. Storage of chloride salts is prohibited except in structures designed to minimize contact with precipitation and constructed on low permeability pads designed to control seepage and runoff.

b. Generators of Hazardous Waste shall provide the Town with copies of all applicable permits provided by State and/or Federal regulators and copies of all annual, incident, and remediation-related reports.

c. Any projects where Water Consumption exceeds the Natural Recharge, as defined in Subsections F and G herein, shall demonstrate through SEQRA how such impact will be mitigated through, for example, compensatory recharge equal to the identified recharge deficit through a combination of artificial on-site or off-site recharge, or provision of compensatory natural recharge areas elsewhere in the Town.

5. Special Conditions for proposed uses within the Buffered Valley Bottom Aquifer BVBA areas and the Upland Aquifer UA areas requiring a Special Permit:
   a. Gasoline service station operators shall provide the Town with copies of all applicable permits provided by State and/or Federal regulators and copies of all annual, incident, and remediation-related reports.
   b. Junkyard operators shall drain fuels, lubricants, and coolants from all cars stored on site to properly permitted above-ground holding tanks, provide to the Town copies of all applicable permits provided by State and/or Federal regulators and copies of all annual and incident reports, provide the Town with an annual summary of numbers of vehicles on site and total gallons of various classes of fluids drained from vehicles and disposal manifests or other documentation of disposition of such fluids.
   c. Storage of chloride salts is prohibited except in structures designed to minimize contact with precipitation and constructed on low permeability pads designed to control seepage and runoff.
   d. Storage of coal and/or cinders is prohibited except in structures designed to minimize contact with precipitation and constructed on low permeability pads designed to control seepage and runoff.
   e. Generators of Hazardous Waste shall provide the Town with copies of all applicable permits provided by State and Federal regulators and copies of all annual, incident, and remediation-related reports.
   f. Any projects where Water Consumption exceeds the Natural Recharge, as defined in subsections F and G herein, shall demonstrate through SEQRA how such impact will be mitigated through, for example, compensatory recharge equal to the identified recharge deficit through a combination of artificial on-site or off-site recharge, or provision of compensatory natural recharge areas elsewhere in the Town .

6. Prohibited uses within the Priority Valley Bottom Aquifer District PVBA and Upland Wellhead Protection UWP areas:
   a. Municipal, private and C&D landfills as defined in 6 NYCRR Part 360-2 and 6 NYCRR Part 360-7.
   b. Land application of septage, sludge, or human excreta, including land application facilities as defined in 6 NYCRR Part 360-4.
   c. Disposal, by burial, of any hazardous waste, as defined in 6 NYCRR Part 371
   d. Large Quantity Generators of Hazardous Waste.
   e. Gas stations and Major Oil Storage Facilities.
   f. On-site dry cleaning.
   g. Junkyards and Junked car lots.

7. Prohibited uses within the Buffered Valley Bottom Aquifer BVBA and Upland Aquifer UA: Land application of septage, sludge, or human excreta, including land application facilities defined in 6 NYCRR Part 360-4.3.

8. General Non-Degradation Standard: No special permit shall be granted unless the applicant can show that the proposed action will not degrade the quality of the groundwater in a manner that poses a potential danger to public health or safety. Compliance with applicable standards, requirements, and permit conditions imposed by federal, state, or county agencies shall be deemed to constitute compliance with this standard.

F. Determination of a Parcel's Natural Recharge

The natural recharge rate for a parcel shall be determined by identifying the soil types on the property, classifying them by hydrologic soil groups (A through D), applying the recharge rates of 20.2 inches per year through HSG A and A/D soils, 14.7 inches/year per year through HSG B soils, 7.6 inches/year through HSG C and C/D soils, and 4.2 inches/year through HSG D soils, and multiplying the recharge rate(s) by the number of acres in the parcel for each soil group

G. Consumption of Water
Water consumption is the net loss of liquid phase water through site activities, plus the water needed to dilute wastewater and other discharges to a concentration equal to 50% of the NYS Title 6 Part 703 Groundwater Standard.

The following table establishes the method to calculate water consumption:

Use	Gallons per day	Multiplied by Dilution factor	Consumption/day
Irrigated Lands (non-agricultural)	Irrigated Acres x 4,000(1)	x 1	= ____________
Uses with Surface Water Discharge	Site activity use x 0.2	x 1	= ____________
Residential Uses with Subsurface Water Discharge(2)	70 gpd/capita	x 6	= ____________
Nonresidential Uses with Subsurface Water Discharge(2)	Daily Use	x 6	= ____________

(1) Applicable for vegetation requiring 1 inch/week irrigation. May be adjusted for vegetation with other water requirements.
(2) Calculate use per NYSDEC intermediate wastewater disposal guide. Discharge must not exceed NYSDEC Title 10, Part 703 effluent limits.

H. Map Changes

1. New Buffered Valley Bottom Aquifer BVBA and expanded Buffered Valley Bottom Aquifer BVBA areas may be established by the Town's Hydrogeologist at the request of the Town, or proposed to the Town by groups of site owners where a new Community Water System source regulated by the NYS Department of Health is proposed, and where the Town's Hydrogeologist concludes or agrees that the water source for the Community Water System and any private wells within or hydraulically downgradient from the new or expanded Buffered Valley Bottom Aquifer BVBA would not be threatened by a Pollutant Discharge originating anywhere within the Buffered Valley Bottom Aquifer BVBA.
2. New Buffered Valley Bottom Aquifer BVBA shall be regional in nature and no single project, or single parcel Buffered Valley Bottom Aquifer BVBA may be proposed.
3. New Upland Wellhead Protection UWP areas, or expanded Upland Wellhead Protection UWP areas, must be defined for the water sources for any existing and future proposed Community Water Systems within the Upland Aquifer UA by their owners, and must be reviewed and approved by the Town's hydrogeologist.
4. The Aquifer Overlay District Map may be modified to reflect new or more accurate geological or hydrological information, provided that the Town's hydrogeologist reviews and approves any such modification.
5. Any new areas or revisions of boundaries made pursuant to this Subsection H shall be placed on the Aquifer Overlay District Map pursuant to the zoning map amendment process in Article X.

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I. Reporting of Discharges
Any person or organization responsible for any discharge of a Hazardous Substance, Solid Waste, Hazardous Waste, petroleum product, or radioactive material shall notify the Town Clerk of such discharge within 24 hours of the time of discovery of the discharge. This notification does not alter other applicable reporting requirements under existing law and applies to all uses and structures, whether conforming or non-conforming in any respect.

J. Non-conforming Uses, Structures, and Lots
See Article VI of this Chapter. For any non-conformity which requires a special permit to expand or change, all requirements of this § 121-15 shall apply to such expansion or change.