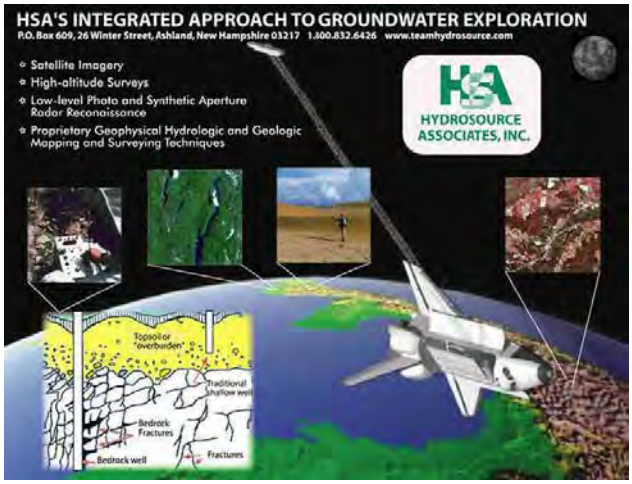
About HydroSource Associates

HydroSource Associates, Inc. (HSA) is a multi-disciplinary group of water professionals whose primary focus is the exploration, development, protection and sustainable management of groundwater resources. Since 1972, our scientists have continually developed a systematic, scientific process of groundwater exploration using satellite and high altitude imagery analysis, structural, tectonic and brittle feature mapping, and modification and use of geophysical instruments and methods developed initially for the search for minerals, petroleum and natural gas. Using these new techniques, we pioneered the process of exploration and development of high-yielding water wells in fractured crystalline bedrock and significantly improved traditional methods of exploration for and design of groundwater sources in karst (limestone) and alluvial, glacial and coastal plain (sand and gravel sediment) environments.

Types of water sources developed by HSA include: potable water; commercial/industrial process water; fire suppression; supplies for heating/cooling and geoexchange systems; snow-making, irrigation and aquaculture water sources; land-based brackish and/or seawater wells that serve as pre-treated feedwater for reverse-osmosis/membrane treatment technologies; and riverbank filtration sources that supply pre-treated raw water for conventional surface water treatment facilities. A good portion of HSA's recent work has included assessment of existing water sources, both existing wells that water systems contract us to assess in terms of their condition, sustainability, and water quality, and wells that are dormant and have been out of operation for some reason. We provide a professional appraisal of their yield, chemistry and sustainability to our clients in support of their decision to purchase. Often, we make recommendations as to how to improve the source either by construction enhancements, source rehabilitation, or some type of water treatment. HSA has also been involved in Aquifer Storage and Recovery (ASR) and artificial recharge projects whereby raw and/or treated surface water is used to recharge underground aquifer systems for later extraction and use. As population has increased and land development has progressed over the years, readily available supplies of uncontaminated fresh water have become increasingly limited. To address this, HSA has expanded its knowledge and experience in evaluation and determination of water source sustainability and proper management. HSA professionals have worked throughout the United States, in South America, Africa, China and the Middle East. Our primary markets are New England, New York, the Carolinas, Georgia and the Caribbean.

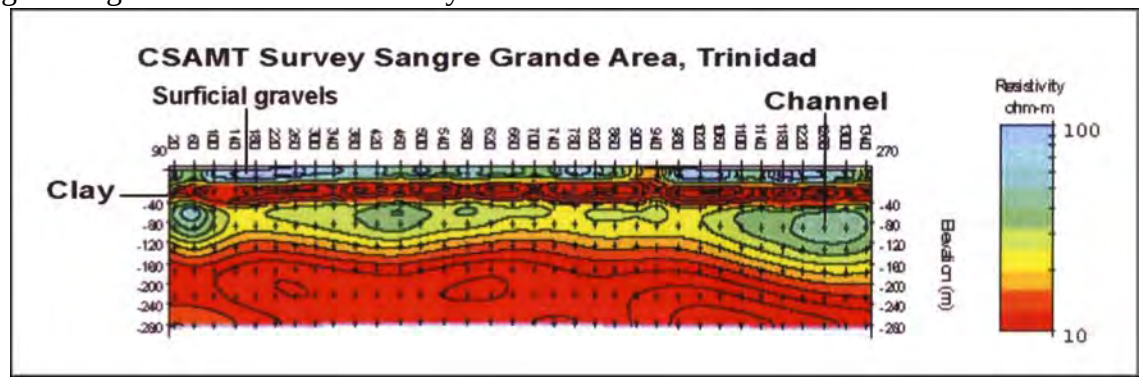
The majority of our work has involved assessing and developing water resources for national governments, cities, towns, villages, community



water systems, homeowners associations, private and pubic water companies, large-scale real estate developers, various types of industries and manufacturing facilities, bottled and mineral water companies, power plants, public and private fisheries/aquacultural operations, agricultural enterprises, vacation hotels and ski resorts, golf courses, and a host of other clients requiring water supplies in the range of 10,000 to several million gallons per day, such as the 19,000,000 gallon per day water sources we recently developed for the federal government of Trinidad and Tobago, or the two wells that produce nearly 9,000,000 gallons per day we located and developed for the Village of Saranac Lake, New York. HSA's track record of success is world-wide, having developed many millions of gallons per day of groundwater supplies for hundreds of clients in hydrogeologic settings and climates ranging from tropical, to temperate, to arid. In fact, many of the wells we have developed for our clients are some of the highest yielding wells in their region.

HSA's water source development approach begins with the assessment of numerous sets of pertinent technical information. Once these data sets are integrated, they provide a preliminary view to broad areas possessing the highest potential for groundwater development. From this point, HSA's professionals correlate the remotely sensed and mapped data with field observations to further refine and delineate areas that are favorable for the development of water sources.

Further refinement is achieved through use of several geophysical tools and techniques which HSA routinely employs. HSA is equipped with a suite of geophysical instruments selected and modified to perform high-resolution investigations of the subsurface. When called for, HSA uses a team approach on large-scale projects that includes the most experienced and qualified resources available, from specialized satellite image processing and data gathering assistance required in the early stages of exploration, to highly skilled geologists with extensive knowledge of the local geology, to three-dimensional modeling experts, to engineering services for final water system construction.



HSA's professional staff are well versed in the design, construction and testing of bedrock and alluvial/ screened wells, having directed well installations and pumping tests in diverse hydrogeologic settings throughout the United States and abroad. HSA's drilling geologists are experienced with the newest drilling and development technologies. We routinely use dual rotary, dual wall, air rotary, mud rotary, eccentric drilling (Odex, Tubex, and Centrex) methods, cable tool, drive-and-wash, reverse circulation, flame-jetting and inclined borehole and horizontal well drilling techniques. Well development methods performed by HSA include surge, water-jetting, chemical treatment, and hydrofracturing. These methods are carefully chosen by HSA based on a thorough understanding of well and aquifer hydraulics and proper well performance diagnosis to be best suited to developing the maximum amount of water from a particular hydrogeologic environment. Decisions on the design of the well, and/or the type of drilling or well development method to use can commonly turn apparent well failures into definite successes.

Once wells are drilled, aquifer testing is conducted to determine safe pumping rates and schedules, as well as to obtain those regulatory approvals routinely required from local, state and/or federal authorities. These pumping tests are often highly specialized, based on differences in well design, hydraulics, and aquifer character-istics. HSA has conducted hundreds of aquifer tests on a wide variety of types of water supply wells and aquifers. The objects of the tests are to provide HSA hydrologists and water resource management specialists with the information to create a sustainable water management plan for HSA's clients. The water management plan ensures that the client receives the maximum benefit from the new water supply, without over-pumping or causing negative impacts to the aquifers or surrounding environment, ensuring that the water system will operate properly and provide water for decades to come. HSA not only possesses experience with approval procedures but also enjoys a stellar reputation with state and federal agency officials, thus ensuring a smooth and expeditious approval process. Not a single groundwater supply developed by HSA has ever been denied approval in any state.

Since its inception, HSA has continually expanded its capabilities, advanced its technology, and successfully applied its groundwater development program over a highly diverse spectrum of geologic and geographic settings. HSA's technical experience currently spans a range of disciplines including geology, hydrology, hydrogeology, geochemistry, geophysics, remote sensing, and water resources management. Several of HSA's staff members also recently completed training and became certified as Combined Grade IA Waterworks Operators. We have an outstanding track record of success, having developed tens of millions of gallons per day of groundwater supplies for numerous clients. We have sited, designed, developed, tested and/or evaluated in some way literally hundreds of groundwater sources for as many clients. Regulatory officials that oversee the permitting of water supplies, especially in our core market areas, know us well, and we are well-respected and well-regarded for the work we do as capable, experienced and ethical professionals.

HydroSource Associates, Inc.
Experience in New York State

HydroSource Associates, Inc. (HSA) is a team of skilled earth scientists that has been successfully exploring for, locating and developing significant, sustainable groundwater sources in New York State for nearly two decades. HSA has worked throughout the Adirondacks and the North Country, all the way from Crown Point on Lake Champlain, to the Town of Hammond on Lake Ontario, to Malone and Chateaugay near the St. Lawrence River. The majority of HSA clients have been water supply systems for municipal entities (e.g., V. of Malone, T. of Elizabethtown, T. of Crown Point, V. of Antwerp, V. of Edwards, T. of Webb's Old Forge Water District, T. of Forestport and others) plus food processing operations (McCadam Cheese - Chateaugay, Crowley Foods - LaFargeville), a Boy Scouts of America camp (Camp Massawepie - Tupper Lake), private schools and others.

Beyond the North Country, HSA has undertaken several projects in Central New York, the Southern Tier, the Catskills and the New York City metro area. HSA has worked as far west as Allegany County in the Southern Tier region where it recently sited and developed a 1,450 gpm sand-and-gravel well for a client in the Genesee River valley.

HydroSource Associates has developed numerous new groundwater sources in fractured bedrock where other firms said it wouldn't be feasible and oftentimes has been able to identify the thickest portion of a saturated sand-and-gravel aquifer which, in turn, has led to the siting and construction of prolific new wells. HSA has accomplished all of this through its sophisticated approach to groundwater exploration which uses several tools including geophysical surveys, analysis of stereo pairs of colored infrared and black-and-white aerial photos, side-looking airborne radar mosaics, and digital elevation models. Coupled with skilled, first-hand geologic field mapping and assessment of previous work done by others, HSA integrates data analyses from these several sources using GIS to create a conceptual model and recommend specific places to test drill and develop production wells. HSA is very familiar with all New York State regulations regarding the development and regulatory approval of new groundwater sources. It enjoys excellent working relationships with professional personnel at the NYS Department of Health, the NYS Department of Environmental Conservation and several NYS county health departments.

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Groundwater Source Siting & Development
Village of Saranac Lake, New York

Village of Saranac Lake, New York. The Village of Saranac Lake formerly used McKenzie Pond as its water source. However, the New York State Department of Health rescinded the Village's drinking water filtration avoidance when monitoring data showed that disinfection byproduct levels in treated water drawn from the pond exceeded EPA standards. At that point, the Village was obligated to filter its drinking water or develop an alternative (groundwater) source. Teaming with two consulting engineering firms, HSA was contracted to investigate the groundwater source alternative which would satisfy the NYSDOH mandate. The engineering firms evaluated two surface water treatment technologies, i.e., membrane and slow sand filtration. However, it was shown that if a suitable groundwater source could be located and developed, it would be significantly less costly than a new surface water treatment facility. The Village was seeking a sustained volume of 1,200,000 gallons per day or 1,700 gallons per minute.

HSA conducted a groundwater exploration program and source development feasibility study. The program was aimed at identifying well sites reasonably close to the distribution system where the necessary quantity of high-quality water could be developed, where the source would be relatively invulnerable to contamination, and where setbacks and other State well-siting requirements could be satisfied. HSA's groundwater exploration effort was documented in a series of reports. A Phase I Groundwater Source Investigation and Evaluation involved review of a range of factors relevant to groundwater, including bedrock and surficial geology, structural geology, groundwater recharge potential, contaminant threats and practical considerations. This resulted in the delineation of four limited areas that were believed to have high potential for groundwater development within which the Village decided to have HydroSource conduct geophysical well-siting surveys. Integrating results from the geophysical surveys with work done in Phase I, HSA identified promising test well sites in two of the areas.

3,000+ gpm Pumping Test – Saranac Lake, NY

A total of five test wells were drilled, three on Village-owned property and two on privately owned land. Three of the wells were subjected to sustained pumping tests and demonstrated that production wells near them would produce water of excellent chemical quality and, very conservatively, could produce water at a sustained rate of as much as 2,500 gpm, i.e., a single well could provide more than 3,000,000 gallons per day capacity and thus replace the McKenzie Pond source by itself.

The Village opted for development of the new groundwater source over a surface water treatment facility and two large diameter production wells (primary and back-up) were installed and tested according to State and federal requirements. Long-term (72 hour) pumping tests were conducted on the wells at the rate of over 3,000 gpm each. It is believed that wells in this location, properly sized and equipped with appropriate pumps, could yield significantly more than this on a sustained basis, perhaps as much as 10,000 gallons per minute. HSA corresponded with and reported to the Village, the NYSDOH, the NYSDEC and the Adirondack Park Agency throughout the entire process to acquire the necessary approvals and source permits.

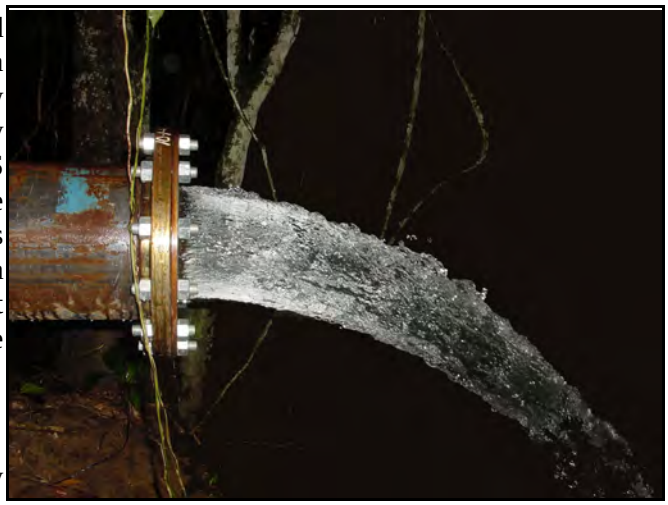
Over Five Million Gallons a Day in Just Two Wells Malone, New York

Client: Village of Malone, New York. The Village of Malone water system, which relies solely on springs, serves a population of approximately 13,000 and four major correctional facilities. The average daily demand is approximately two million gallons per day. The New York State Department of Health informed the Village that it would have to either replace their spring supply with groundwater wells or construct a surface water treatment plant. The Village opted to construct groundwater wells near their spring supply. The wells would have to be capable of supplying the Village with a minimum of two, and ideally up to three million gallons per day (2-3 mgd) of water. Based on prior work by other consultants, it was initially suspected that this volume would require eight to ten (8-10) production wells. However, several test wells previously drilled by other professionals near the springs were drilled to only 100 feet and did not penetrate the full thickness of the aquifer. The Village contracted with HSA to conduct a groundwater exploration and development program including geophysical surveying and test drilling, installation and testing of new production wells, and completion of the regulatory approval process for the new wells. To date, HSA has conducted gravity and electrical resistivity geophysical surveys and test well drilling. This work was conducted in the same area as the prior consultants' work. HSA's investigations suggested that the overburden was up to 250 feet thick in some areas, or nearly 2.5 times the thickness determined to be present by others' prior work for the Village. Subsequently, three test wells were installed by HSA to test the full thickness of the underlying sand-and-gravel aquifer. Two test wells were installed to over 225 feet in depth and one test well was installed to approximately 170 feet in depth. HSA's test drilling program indicated a prolific sand-and-gravel aquifer at depths greater than 100 feet. Based on preliminary yield test results, it is anticipated that the entire volume required to meet the Village's demand can be developed. Preliminary water quality analyses indicate excellent quality water. A 20-inch diameter production well has been completed with 88 feet of screen. A pumping test with a rate of approximately 2,000 gpm (3 mgd) was conducted on the first large diameter well. The long-term safe yield of this single well should provide the entire desired new capacity of the Village, as opposed to previous expectations of eight to ten production wells. In addition, the newly discovered aquifer appears to have the capability to provide several million gallons per day from multiple closely-spaced wells. A second 20-inch diameter production well has also been developed at a second site nearby as a back-up supply for the Village.

Groundwater Source Siting & Development
Houghton Water & Sewer District
Caneadea, New York

Client: Houghton Water & Sewer District, Town of Caneadea, New York. At the time HydroSource began its work for the Houghton Water & Sewer District in northern Allegany County, the District's existing water supply wells were located south of the hamlet of Houghton. These wells were located based on well siting efforts and the installation of thirteen (13) test wells sited and installed by other consultants many years prior.

Because the aquifers in the Caneadea area produce water with moderate levels of naturally occurring iron and arsenic, the District had planned to construct a water treatment facility for their removal. That facility would be located on a large parcel of land adjacent to the District's wastewater treatment facility northeast of the community. Rather than connect the existing production wells to the planned treatment facility, which would be over a mile away, the District decided to pursue development of a new groundwater source in closer proximity to the planned treatment facility. It was also hoped that a new source could provide a higher sustained yield, reducing the need for future water source capacity development. The goal was to develop a minimum of 900,000 gallons per day (625 gpm) of new capacity.



HydroSource, working with a well drilling company and a consulting engineering firm, located and developed a new source and an adjacent backup source near the new treatment facility. These sources meet the regulatory requirements of the NYS Department of Health, the NYS Department of Environmental Conservation and the Allegany County Health Department. HSA's services included geologic and hydrologic evaluation of the area and well-siting geophysical surveys to identify the most promising locations for test well installation. Based on the results, two promising test well sites were identified.

Based on an initial brief pumping test, the very first test well that was installed demonstrated the ability to easily satisfy the District's yield goal of 625 gpm. Two production wells, a primary and a backup, were installed at the site and tested according to regulatory requirements for new source permitting. Whereas the goal was to develop a minimum of 625 gpm (900,000 gallons per day) of new source capacity, the wells were approved and permitted by the regulatory agencies at 1,450 gpm (over 2 mgd) each! HSA received commendations from the local regulators for its work.

Groundwater Development of a New Fireflow Source for Otis Technology Inc. Lyons Falls, New York

The Otis Technology, Inc. facility at the Village of Lyons Falls, New York, was in the process of undergoing an expansion when it was determined that the public water supply for the Village was inadequate to meet the needs of their new fire suppression system. The facility needed 1,200 gallons per minute (gpm) constantly, for two hours' time, to satisfy the fire safety requirements of the State, county, and the National Fire Protection Agency. Several options were considered, including building a heated onsite storage tank (to prevent ice formation), improving the Village water system infrastructure to meet Otis' fire flow needs, and developing an onsite groundwater source. It was determined that, if a groundwater source could be developed that was capable of meeting the requisite flow rate, it would result in a significant cost savings for development, operation and maintenance in comparison to the alternatives.

HSA conducted a groundwater feasibility program to determine whether site conditions could support the water needs of the facility. A series of geophysical surveys were performed that were designed to assess the subsurface conditions, including the depth to bedrock and the types of overburden materials present. The surveys indicated that depth to bedrock was as much as 150 feet below the facility and that a highly productive aquifer may be present beneath the area. HSA subsequently oversaw the installation of two test wells designed to test the subsurface conditions at the site. Both wells were subjected to sustained pumping tests and showed that the aquifer located beneath the facility was capable of meeting the flow needs of the facility. At this point, Otis Technology, Inc. opted to continue with the development of a groundwater source to supply the facility fire protection system, and authorized the construction of a production well on the site.

One large-diameter groundwater well was installed adjacent to the test well that was determined to have the most favorable subsurface conditions. NFPA rules for yield testing a groundwater well require that the flow rates be tested at a minimum of 150% of the required flow rate for a total of eight hours. After construction, the well was tested at a rate of 1,900 gpm. Well performance during the pumping test greatly exceeded expectations, and the well was subsequently approved by the presiding regulatory officials as the new fire flow source for the facility.

Free Flowing Sources
Elizabethtown, New York

Client: The Town of Elizabethtown, New York. The Town of Elizabethtown, located at the eastern edge of the High Adirondacks region in Essex County, suffered frequent water supply shortages from its well field (four shallow sand-and-gravel wells) and adjacent spring source. HSA conducted hydrogeologic investigations to assess local and regional surficial and bedrock geology specifically in regard to a new groundwater source. The investigations included on-site geologic mapping, electromagnetic and gravimetric geophysical surveys and a groundwater recharge assessment. The setting for HSA's highest priority drilling target was in a confined aquifer having a laterally extensive confining clay layer above it. The test well drilled there flowed freely at a 100 gpm rate. That flow alone exceeded the Town's four wells and spring source. An eight-inch diameter, screened production well was installed adjacent to the test well. The total depth of well is 80 feet and it is screened from 65 to 80 feet. The 72-hour constant-rate pumping test resulted in the recommendation of 250 gpm (324,000 gpd) as the safe-yield pumping rate. The test well serves as a backup (along with the previously existing four shallow wells). The combined free-flow from these two wells is 125-150 gpm. The Town uses these wells in their free flowing state because its treatment and storage facilities are located sufficiently down gradient, but the primary well has a pump installed as further backup. HSA prepared the final report required for submittal to the New York State Department of Health and the New York State Department of Environmental Conservation for permit approval.

McCADAM CHEESE COMPANY
CHATEAUGAY, NEW YORK

The Village of Chateaugay, in the St. Lawrence River watershed, wanted to upgrade its water system. To qualify for funding assistance, the majority of its users had to be domestic users. They were not. In fact, the largest single user was a dairy processing plant that manufactured cheese and which accounted for a large amount of equivalent connection units. If the processing plant could rely entirely on its own supply, then the Village would be eligible for very attractive state and federal funding assistance. HydroSource Associates was contracted by the processing plant to investigate the possibility of sighting and developing a well on the processing plant property that could produce 400,000 gallons per day on a sustained basis. That is, this was to be a well with a safe yield of approximately 275 gallons per minute. The predefined search area was very limited.

The processing plant had one bedrock well that provided a portion of its total needs, located to the west of the plant. It was noted that that well was 300 feet deep and intercepted several bedrock fractures. Based on its review of various geologic, hydrogeologic and engineering data, reports and information, remote sensing/fracture trace analyses of different types and scales of aerial photography, first-hand geologic field mapping and detailed geophysical surveys, HSA identified a potential well site just 650 feet east of the processing plant.

An eight-inch diameter bedrock well was drilled to a depth of 475 feet. While small fractures were intersected at 160, 263, 268 and 293 feet, a major water-contributing fracture was hit at 472 feet. A three-day constant rate pumping test helped establish that a safe yield for this well is in excess of 500 gallons per minute (i.e., over 720,000 gpd). The proverbial "bottom line" of this effort was a classic win-win situation whereby the processing plant was able to secure its own reliable, water supply and the Village was able to secure very inexpensive funding to provide improvements to its water system, providing savings over time to both parties.

HAMLET OF OLD FORGE
NEW YORK

Old Forge, a summer resort community and winter snowmobiling center in the southwestern part of New York State's Adirondack Mountains, faced the prospect of having to construct a costly water treatment plant to process its surface water supply in order to meet the EPA's new mandatory drinking water standards. Previous studies undertaken on behalf of the Old Forge Water District had reached conclusions that the area's geologic setting was not conducive to the development of high-quality groundwater sources. Other professionals said that the area possessed unconsolidated materials of depths too shallow to yield much water. HSA's fully integrated exploration effort revealed the existence of buried troughs within the bedrock which may have been formed as a result of variations in erosional resistance among different types of bedrock, or by fractures caused by ancient earthquakes. The result was the discovery and development of a plentiful, high-quality groundwater source within 400 feet of Old Forge's existing distribution main. Two gravel wells, 164 and 236 feet deep, were drilled, developed and placed on-line. The sustainable yield for each well exceeds one million gallons per day. Chemical analyses of the water have proven it to be superior, better than bottled water, quality. Old Forge no longer had to consider building a water treatment plant. The cost savings for Old Forge are more than 1 million dollars.

New Groundwater Source Development
Town of Mexico, New York

Town of Mexico, New York. The Village of Mexico had a reliable supply and good water quality from a series of screened gravel-pack wells on its property along the western edge of the Town. However, a separate water system operated by the Town of Mexico was in need of a new water source. After consulting with HydroSource as to whether sufficient additional source capacity to supply the Town may be available at the Village's property, the Town coordinated with the Village and focused its efforts to site and develop a new groundwater source on the Village's wellfield property. HSA conducted hydrogeologic investigations to assess the Village-owned property in an effort to locate and develop a new groundwater source for the Town that would provide sufficient source capacity, acceptable water quality, and satisfy the regulatory requirements of NYS Department of Health, NYS Department of Environmental Conservation and the Oswego County Health Department. HSA's investigations prior to installation of the production well included research and evaluation of local hydrogeological information and surficial geology. A critical component was an assessment of the potential for pumping interference between a proposed new well for the Town and the Village's existing wells to ensure that withdrawals by the Town would not adversely impact the Village's water sources. After initial well testing and analyses by HSA demonstrated that impacts were unlikely, HSA followed with subsurface investigation using geophysical surveying, test well drilling, and preliminary pumping and water quality tests. A large-diameter production well was then designed and constructed by HSA for the Town. As the project progressed, the NYSDOH, NYSDEC and OCHD were consulted regularly and a final source permit was acquired from them. The permitted safe yield of the well was 650,000 gpd.

New Groundwater Source to Replace Springs
Antwerp, New York

Client: Village of Antwerp, New York. For many years the Village of Antwerp had relied on a spring source for its entire water supply. That spring was located wholly within the Fort Drum Military Reservation, a major U.S. Army training base. In the year 2000, the Village of Antwerp was notified by the U.S. Department of Defense that the Village's 99-year lease of the spring property would be terminated in two years and the Village would have to develop a new water source elsewhere, outside the bounds of the Army base. HSA was retained by the Village to conduct its three-phase groundwater exploration program in very challenging hydrogeologic terrane with the realistic goal of locating and developing a source that could produce 60 to 100 gallons per minute on a long-term, sustainable basis. At the end of its first phase of investigation, HSA had delineated six Favorable Zones (three primary and three secondary) and conducted geophysical surveys (magnetic and electromagnetic) in four of those Zones (three primary and one secondary). A total of five test well locations were chosen in two different Favorable Zones. One test well intercepted a major fracture zone and yielded over 300 gallons per minute. However, an unexpected water quality issue arose (slightly elevated radium levels under the new EPA rule but well below the old standard) at this site. It was decided to try another Favorable Zone test well site where it was felt this problem could be avoided. Three test wells were drilled within 500 feet of one another. The first yielded about 12 gallons per minute, the second less than five (5) gpm and the third yielded over 350 gpm (by air lift measurement). The wells ranged from 400 to 600 feet in total depth with the high-yielding well having a total depth of 491 feet. The radium level of the water was below the newly established EPA contaminant level for this element. The high-yielding test well has since been converted to a production well and a second (backup) well has been installed nearby. Long-term pumping tests have been conducted and a safe-yield pumping rate of 150 gpm for each well has been recommended.

VILLAGE OF MARATHON, NEW YORK

Since May 1999, HydroSource Associates, Inc. (HSA) has been working for the Village of Marathon, New York, to develop a new groundwater source that meets the Village's maximum daily demand and the regulatory requirements of the New York State Department of Health (NYSDOH), Cortland County Health Department (CCHD), the New York State Department of Environmental Conservation (NYSDEC), and the Susquehanna River Basin Commission (SRBC).

The Village had been served by three existing wells. In recent years, one well has been determined to be under the influence of surface water. Another well was put out of service due to volatile organic compound (VOC) contamination. Water from the third well, while potable, has an elevated manganese concentration that approaches a level that is 40 times the secondary Maximum Contaminant Level (MCL) of 0.05 milligrams per liter. Options such as treatment of Well #3 to reduce the manganese concentration, or surface water filtration were prohibitively expensive. For these reasons the Village sought to develop a new groundwater source capable of providing a sustainable yield of at least 250,000 gallons per day.

The Village of Marathon lies in Cortland County, within the Tioughnioga River Valley. The area is located in the Appalachian Plateau province of south-central New York State. This province is characterized by layers of flat-lying sedimentary shale and siltstone, which typically are not hosts of high-yielding bedrock aquifers. On the flanks of the river valley, the bedrock is overlain by glacial till, while in the valley, a trough has been eroded into the bedrock, and this trough is filled with unconsolidated surficial deposits, including limited areas where sand and gravel aquifers exist.

A number of previous studies of the groundwater development potential of the area had been conducted by others prior to HSA's work for the Village. These included engineering and hydrogeologic studies by both professional engineering companies and the United States Geological Survey. Likewise, a number of test well drilling attempts had been made.

One study concentrated on the sand/gravel aquifer in the river valley, but also made a brief assessment of the till/bedrock aquifer. The study concluded that bedrock wells generally have insufficient yield for municipal purposes. Based on data from a single 245-foot deep well, the study concluded that the greater depth of this well was responsible for high salinity, total dissolved solids, and iron.

Abundant data exists on the surficial deposits of the area, largely as a result of previous drilling efforts by the Village. The various wells show considerable variation in water-bearing capacity of the overburden, and water quality varying with location. The maximum depth of these overburden wells was 45 feet, which approached the upper limit of overburden depth in the Marathon area, according to existing knowledge prior to HSA's efforts.

HSA conducted its hydrogeologic investigations to assess the local and regional surficial and bedrock geology in regard to groundwater potential. HSA's investigations have included a recharge assessment, surficial and bedrock geologic mapping, geophysical surveying, and test drilling. During the initial phase of this project, HSA identified several areas for detailed groundwater exploration work that were distributed around the Village. Geophysical surveys were conducted in several of these areas to assess the nature of the overburden, where it may be thickest, and potential for development of a sand-and-gravel aquifer. In a limited number of areas, geophysical surveys were performed to assess whether the potential may exist for bedrock well development. The geophysical surveys confirmed that depth to bedrock (overburden thickness) was limited to less than 50 feet, but did indicate the potential existence of productive overburden deposits and areas of intensified bedrock fracturing in specific areas.

Based on these results, six test wells sites were recommended by HSA and drilled. Two test wells indicated favorable conditions for developing new well sources for the Village. One well installed to test for an underlying sand-and-gravel deposits encountered overburden thickness of approximately 52 feet below ground. This represents one of the thickest sequences of overburden deposits known to occur in the Marathon area. This is a testament in itself to HSA's exploration program as one goal was to test drill in areas where the overburden and/or aquifer thickness was greatest. A preliminary pumping test performed on the test well indicated that potential production capacity could be substantially increased via a properly designed and thoroughly developed large diameter well.

Another test well, installed approximately 600 feet away to test the potential for an underlying fractured bedrock aquifer, was drilled to over 280 feet in depth and yielded approximately 100 gallons per minute of potable quality water during airlift yield testing. A preliminary pumping test indicated that well yield could potentially be increased with proper borehole development and an increase in borehole diameter. Water quality analyses of samples collected from both the screened sand-and-gravel well and the bedrock well during preliminary pumping tests indicated potable quality with acceptable levels of manganese.

Two 10-inch diameter, naturally developed, screened sand-and-gravel wells, one primary well and one mechanical back-up well, and an 8-inch diameter bedrock well have since been installed at the site. Aquifer testing (pumping tests) are underway per NYSDOH, CCHD, NYSDEC, and SRBC requirements to determine impacts on nearby wetlands and surface water

bodies, to calculate final well safe yield, aquifer parameters, etc., and to collect water quality samples for full EPA-required analysis. Preliminary estimates of sustainable yield from the screened wells indicate that as much as 400,000 gallons per day is likely. The large diameter bedrock well is perhaps the most interesting, as its sustainable yield is on the order of up to 250,000 gallons per day - a very significant rate given the fact that the area's bedrock is known to not be conducive to high-yield bedrock well development.

Very significant cost savings were realized by the Village as a result of HSA's work. First, HSA used the test wells as monitoring wells, satisfying the requirements of the NYSDEC and SRBC, that require that multiple monitoring wells be installed prior to aquifer testing in order to determine aquifer characteristics and pumping impacts. No additional monitoring wells were required. As such, the Village was spared the significant added expense of monitoring well installation. Furthermore, HSA's exploration activities identified a site for the new wells that is only 2,800 feet from the Village's existing pumphouse and transmission main that service the Village's high-manganese well. By doing so, after conducting the proper investigations to determine that the new site is hydraulically disconnected from the high-manganese area, the Village is able to use the existing pumphouse, valves, meters, etc. without having to abandon them and start over. This alone will save the Village hundreds of thousands dollars in project cost.

New Bedrock Well
Forestport, New York

Client: Town of Forestport, New York. Served by two shallow bedrock wells located at the far northern edge of its service area, the Town of Forestport, an Adirondack community in the northeast corner of Oneida County, had attempted on several occasions and over a span of at least three decades, to rehabilitate their declining wells and find other sources. Maximum output of the two adjacent wells, operated alternately, was a little over 60 gallons per minute. This was not enough to meet peak demand. HSA was selected to search for an additional groundwater source in either a sand-and-gravel setting or in fractured bedrock. The deepest recorded bedrock well in the Town's service area was 140 feet. HSA conducted its exploration program, including geophysical surveys using electrical resistivity and gravity methods, and sited and drilled test wells in both sand-and-gravel and bedrock aquifers. One bedrock well, located almost in the center of the Town's distribution system, was drilled initially to a depth of 500 feet and then deepened to 700 feet. The well's safe yield is rated at 50 gallons per minute, fully satisfying the Town's needs when combined with its existing sources. Once the bedrock well was proven, the Town decided not to pursue additional and very promising sand-and-gravel test well sites. Nevertheless, these sites have been identified and can be protected for future use should the need arise. The project received regulatory review and approvals from the Oneida County Health Department, the NYS Department of Health and the NYS Department of Environmental Conservation.

Later, the Town hired HSA to redevelop the system's two original bedrock wells, and determine the source of sediment that chronically entered one of them. Little construction information was available on these wells. HSA surveyed both wells with a video camera, and found that the water-bearing intervals had been outfitted with wire-wrap screen at some point after they were originally drilled. Using the knowledge gained from the video survey, HSA designed and oversaw the development process, which involved systematically agitating the screened depth intervals using a surge block, and alternating surging with pumping to remove a large volume of accumulated iron bacterial sludge. Following development, HSA conducted pumping tests on both wells, and used the results to estimate the degree to which the original yields had been restored. HSA explained the sand production problem, and recommended that the Town schedule periodic redevelopment efforts to reduce the risk of permanent loss of yield.

Replacement of a Dwindling Water Supply
Edwards, New York

Client: Village of Edwards, New York. The Village of Edwards, New York is located at the western edge of the Adirondack Mountains just outside the boundary of the Adirondack Park. For many decades of the past century, the economic backbone of the Village was the mining of iron and zinc ores. Those activities ceased in the 1970s and 1980s. The Village had relied for many years on several low-yielding bedrock wells and the most prolific one had declined to a safe pumping yield of 30 gallons per minute by the 1990s. After the Village had contracted the drilling of several unsuccessful test wells, HSA was contracted and conducted its initial Phase I study which resulted in the identification and delineation of five different limited areas that have conditions favorable for developing groundwater sources. Two of the areas were in potential sand-and-gravel aquifers and three were in fractured bedrock zones.

From more detailed geological investigations and geophysical surveys, HSA was able to pinpoint the locations of proposed test well sites in both sand-and-gravel and fractured bedrock settings. The test well in the sand-and-gravel setting penetrated more than 240 feet of layered sand, gravel, silt and clay but additional well development was not pursued because the overburden was highly layered and would have required very expensive well design and development. Instead, the Village accepted HSA's recommendation to drill two bedrock test wells. The second of the two wells drilled was

at a site that had been selected because the first-hand observation during geologic field mapping and confirmation from gravimetric surveys led HSA to suspect that there was a previously unmapped contact and possible fault zone between marble and granite formations. The test well, drilled to 273 feet, did indeed intercept first granite then marble. The Village hit the jackpot. Needing a safe-yield of 100 gpm (144,000 gpd) to meet Village needs, this well has proven to have a safe yield of over 180 gpm. All regulatory approvals have been granted and the Village now has a safe, reliable water supply for many years to come.

New Groundwater Sources for Natural Bridge, New York

HydroSource Associates, Inc. has successfully completed its project of locating and developing new water sources for Natural Bridge, a small community near Watertown in northern New York. For years, Natural Bridge had been relying primarily on two very shallow, large-diameter dug wells to supply its distribution system which, in turn, served only a portion of the community. Seasonal shortages were experienced and the well sites were susceptible to being contaminated by nearby pollution sources. It was determined that this hamlet needed a reliable source that could produce a sustained yield of 60 gallons per minute on a long-term basis. This would allow for the expansion of the system as well.

As part of a larger program to improve and expand Natural Bridge's water system, HydroSource conducted its three-phase exploration program. After delineating three separate groundwater Favorable Zones that offered promise of either sand-and-gravel or bedrock wells and conducting geophysical surveys in two of them, test well drilling indicated that while sand-and-gravel wells would be marginal, bedrock wells would provide the desired supply.

HydroSource developed two bedrock wells. One well has a total depth of 260 feet, is six inches in diameter and has a safe yield of 75 gallons per minute. Nearby, a second well, which can be used as a mechanical backup or alternated in operation with the first well, is 300 feet in total depth and is eight inches in diameter down to 260 feet and six inches in diameter from there to the bottom of the borehole. The safe yield for it is 60 gallons per minute. In an emergency, such as fire, the wells can be operated together at a safe yield of over 100 gallons per minute.

These wells are located in the center of the expanded distribution system, providing substantial development cost savings to tie into the system. Detailed water quality analyses indicate that the water is fully potable and is outstanding in overall quality.

New Water Source for Sandy Creek/Lacona Joint Water Works

HydroSource Associates, Inc., a team of experienced geoscientists based in Ashland, New Hampshire, has located nad developed yet another source of plentiful, high-quality drinking water for yet another New York State client. While the Villages of Sandy Creek and Lacona were hoping for a consistent new supply of 250,000 gallons per day, they got far more. Here's the before and after.

Before. The Sandy Creek/Lacona Joint Water Works were relying on four wells. Two of the wells were shallow, gravel-packed dug wells that were 30 feet in total depth. They were installed in the 1940s. A third "well" is a series of perforated well tiles placed in a large excavation and backfilled in 1989, is a conventional screened sand-and-gravel well, also about 30 feet in depth. Even when taken all together, these wells did not provide enough volume through the year. Furthermore, the wells are adjacent to an active railroad line. Given the age of the wells and the way they were constructed, they may be quite susceptible to contamination from any hazardous material that could be released in a derailment and from herbicide application for weed control along the railroad right-of-way.

After. The primary task for HydroSource was to find and develop a new groundwater source that would lessen the threat of contamination from railroad activity and provide a reliable, long-term water supply of adequate volume and quality to satisfy the needs of Sandy Creek and Lacona for many years to come. HydroSource conducted its proven systematic search, which included geophysical surveys and on-site geologic mapping, to identify test well drilling targets. The most promising place was an area north of Lacona and east of the railroad on property owned by Hanson Aggregates where the sand-and-gravel deposit appeared to be thicker than the norm for the area.

An eight-inch diameter, screened test well was installed in the sand-and-gravel aquifer and a preliminary measurement showed the well to be capable of yielding 175 gallons per minute (252,000 gallons per day) even before any real well development took place. After converting the test well to a backup production well, a long-term pumping test was conducted at 225 gallons per minute (324,000 gallons per day) and demonstrated that it would be okay to pump that well at that rate on a sustained basis.

A primary 16-inch diameter, screened sand-and-gravel production well was subsequently installed near the backup well. The long-term pumping test for this well was conducted at 475 gallons per minute (684,000 gallons per day) and the water quality samples sent for laboratory analyses were found to be of excellent quality. The total depth of both wells is approximately 50 feet.

The Joint Water Works' consulting engineer, Dodson & Associate of Schenectady, has been coordinating the HydroSource Associates effort with other water system improvements and is now in the process of obtaining the required permits from the regulatory agencies.

SKYLAKE, GEORGIA
New Bedrock Well Water Source

Nestled in the Blue Ridge mountains not far from the Georgia/North Carolina line is the upscale, unincorporated community of Skylake, in White County and about a two-hour drive north of Atlanta. Designed for 540 building lots, this 1,350-acre rural residential development lies in the historic Sautee Valley. In the late 1990's, Skylake was growing and a need for an additional water source became apparent. At that time, Skylake was served by three wells, two having safe yields of 30 gallons per minute and the third slightly less than that.

HSA conducted a three-phase groundwater exploration and development program, including the use of well-siting geophysical surveys and detailed geologic analysis. The goal was to locate and develop an additional groundwater source capable of sustainably providing 100,000 gallons per day. HSA identified and recommended sites where test wells be drilled, each to a depth of 600 feet. The well sites were selected to intersect fractures at depth in the crystalline bedrock. Only one test well was necessary as the first, and only, test well encountered a highly fractured zone such that at 314 feet below the surface, the drilling rig flooded out and drilling had to be halted. A long-term pumping test (72 hours) demonstrated to the Georgia Environmental Protection Division, the state regulatory agency responsible for issuing a permit to operate the well, that 300,000 gallons per day could be pumped safely and sustainably.

Over 1 MGD in a Single Piedmont Bedrock Well Spartanburg County, South Carolina

Client: The SJWD Water District, Lyman, South Carolina. In the process of conducting Phase I of its groundwater exploration program for the District, HydroSource made a routine inventory of existing wells in and around the District's service area and observed that the highest yielding well was located in northern Spartanburg County and had a reported yield of 190 gallons per minute. In an effort to learn more about the well, HydroSource discovered that it was already owned by SJWD but was not being used. The District had purchased it and other wells from Piedmont Water Co. a few years ago. HSA recommended that the District investigate the condition of the well and District retained HSA to do so. Original well records were sketchy at best and relatively little was known about the well other than it was an eight-inch diameter bedrock well approximately 110 fee in total depth. A 24-hour pumping test previously done by others had indicated the 190 gpm yield. HSA conducted a downhole camera survey and found that the well bore had significant bedrock fractures at 85 to 96 feet and had a total depth of 109 feet. Since records do not reveal the reason why the well was as shallow as it was, it was assumed that the yield attained by the original well depth was either sufficient for the needs at the time or that the yield encountered at the time of drilling was too much for the equipment being used to go deeper. The camera survey did not reveal fractures at the very bottom. Given HSA's knowledge of and experience in Piedmont geologic structures, it was strongly suspected that more and perhaps larger water-bearing fractures lay below the current depth of the well and thus HSA recommended that the well be deepened significantly, to a total depth of 400 feet or more. HSA assisted the District in obtaining the required permit from South Carolina DHEC to deepen and reconstruct the well and arranged for the contracting of a driller. More pertinent information became evident as drilling occurred, that is, some caving had occurred and that there was still a pump in the well, buried beneath the debris in the original well bore. A number of small fractures were encountered as the well was deepened, adding to the well yield. Then, at 360 feet, a major fracture was intercepted and the yield increased dramatically. The yield was estimated at over 700 gpm (1 million gallons per day)

Added Yield from Bedrock Wells
Locke Lake System
Barnstead, New Hampshire

Client: Pennichuck Water, Locke Lake Water System, Barnstead, NH. Pennichuck's Locke Lake Water System had been served primarily by two bedrock wells drilled in the 1980's. The yield of Well BRW #13, the shallower of the two wells, had fallen from an initial reported value of 60 gpm to 20 gpm by 2006. Pennichuck hired HSA to help it increase the well's yield.

HSA reviewed available records on BRW #13, which had not been logged when it was drilled. HSA supervised deepening of the well from its initial depth of 300 feet to 700 feet, and logged the well as it was being deepened. The well's yield increased from 20 to 80 gpm after passing through a two-foot-thick fracture zone at a depth of 470 feet.

HSA consulted with the New Hampshire Department of Environmental Services (NHDES) to reach agreement on the steps that would be necessary to re-permit this pre-existing well as a public water supply. HSA then planned and conducted a 48-hour constant rate pumping test, during which water levels were monitored in BRW #13 and two neighboring wells. HSA documented the test in a report that was submitted to NHDES, which approved continued use of the deepened well.

During the deepening and re-permitting of BRW #13, Pennichuck realized that HSA had previously recommended another test well site on the same property that had never been drilled. The undrilled site had been chosen based on geophysical surveys HSA had conducted for a previous system operator many years before. The site had been identified as the most promising of several sites based on the strength of the associated geophysical anomaly, but it had not been drilled because construction of several hundred feet of access road would have been necessary to reach it.

HSA re-staked the original site based on records in its files, since the original client records had been lost. Well BRW #15 was drilled to a depth of 662 feet. HSA logged the well, and worked with the driller to deal with a series of drilling problems. The well's yield increased steadily as it was drilled through a succession of fracture zones. The planned well depth had been 700 feet, but high flow volumes made it necessary to bring in an auxiliary air compressor when the six-inch-diameter hole had reached 555 feet. Drilling was eventually stopped at 662 feet, when the combination of depth and high water volumes resulted in very slow drilling rates. The well's airlift yield at the final depth was 125 gpm, by far the highest yield in the wellfield. After discussions with NHDES, HSA conducted a four-day constant rate pumping test under the well siting regulations governing large community wells, and obtained NHDES approval to add the new well to the Locke Lake system.

BLUE RIDGE RURAL WATER CO., GREER, SOUTH CAROLINA

HydroSource Associates was retained by Blue Ridge Rural Water Company (BRRWC) in Greer, South Carolina, to locate and develop new groundwater sources. BRRWC currently operates and maintains two water systems which provide potable water to an extensive area within the Inner Piedmont and Blue Ridge physiographic provinces. One is the "Mountain System," a system purchased from the developer of The *Cliffs at Glassy* real estate development on Glassy Mountain. The other system is the "Piedmont System," which encompasses the remainder of BRRWC's service area.

The *Cliffs at Glassy* is an upscale, gated residential development which includes 800 residential service connections and an 18-hole golf facility. The flanks of the development are marked by steep slopes, typical of the Blue Ridge Escarpment, rising nearly 2,000 feet within a horizontal distance of only two miles. This situation precludes the BRRWC from pumping residential water supplies from their Piedmont service area to the development, which is at the top of Glassy Mountain. Consequently, BRRWC uses bedrock wells as the sole water supply source for the mountaintop community. A shortage of adequate supply from existing bedrock wells prompted BRRWC to explore for new groundwater sources on top of Glassy Mountain. BRRWC chose to utilize HSA to locate and develop these new groundwater sources.

Previous wells on Glassy Mountain had been located based on basic information, including topographic features such as valleys or draws, the presence of favorable property ownership, and logistical considerations such as the distance from treatment facilities, and other "matters of convenience". These efforts failed to consider the precise location of potentially water-bearing bedrock structures (i.e., fractures), and the degree and direction of structural dip. Of the more than 20 wells drilled prior to HSA's undertaking the project, only seven were usable, representing a success ratio of 35%. The average yield of these seven wells was less than 44 gallons per minute (gpm). If the average is based on the total number of wells drilled, it becomes less than 20 gpm per well.

HSA recommended to BRRWC that it was essential that new groundwater supplies tap deep, productive bedrock fractures to achieve substantial well yields and minimize interference with the existing wellfield. None of the wells drilled previously in the area intersected significant deep-lying bedrock fracture zones.

HSA conducted groundwater exploration within an area of approximately 2.1 square miles on top of Glassy Mountain using remote sensing analyses, detailed geologic mapping, downhole investigations of existing wells, and well-siting geophysical surveys to identify three potential test well target sites within the project area, and ranked these target sites based on anticipated

potential yield. For logistical and land ownership reasons, BRRWC chose to commence test well drilling on the third-ranked test well target. The one test well that was subsequently constructed intersected a major water-producing fracture at a depth of 597 feet below ground surface, i.e., the very deep-bedrock structure that was suspected to be present. Deeper drilling could not be performed as the capability of the drilling equipment was overcome by the large volume of water produced by the fracture zone. A pumping test demonstrated the sustainable yield of the well to be at least 200 gallons per minute (approximately 300,000 gallons per day), or more than 10 times the average yield of all the previous wells drilled in the area. Water samples taken at the end of the pumping test exhibit excellent water quality. HSA oversaw acquisition of all the necessary permits for use of the well as a drinking water supply and assisted BRRWC's engineer with the pumping system design.

New Groundwater Source Development
Town of Belmont, New Hampshire

The community water system operated by the Town of Belmont, New Hampshire, had used two gravel-pack wells as its water source. Their combined yield was approximately 300 gallons per minute, and in many respects they had been an excellent water source for the town. However, the wells had seasonal color problems, and consistently high iron levels. The water quality problems appeared related to the wells' proximity to an area of filled wetlands. The large mass of buried organic material produces a halo of low pH in the adjacent aquifer, which in turn produces high iron levels and other water quality consequences. The Town decided to try siting a well in another location on the same property, but far enough from the mass of buried organic material to avoid the attendant water quality problems.

After evaluating site conditions and performing preliminary well tests and production well design calculations, HydroSource prepared the Preliminary Report that is required under the regulations governing large groundwater withdrawals and siting of large community wells in New Hampshire, and submitted it to the New Hampshire Department of Environmental Services (NHDES). The report included delineation of an withdrawal impact area within the watershed, a set of proposed well and aquifer testing and monitoring protocols, and other information NHDES needed to confirm the feasibility of permitting a large new community supply well at the proposed site.

After receiving NHDES approval, HydroSource oversaw construction of a new 12” x 18” artificial-pack well and performed a multi-day pumping test on the new well. During that test, the well was pumped steadily for five days, with water levels measured in the pumping well and in numerous surrounding wells during a period totaling about three weeks. The test was a challenging one. It was run in February, and a major snowstorm and very cold conditions made operations difficult.

HydroSource produced the Final Report that is required under the large groundwater withdrawal and community well siting regulations. The report, a substantial document, included results and analysis of the pumping test hydraulic information, along with results of water quality testing. NHDES approved the new source at a flow rate of 648,000 gallons per day (450 gallons per minute). The yield of the new well exceeds the Town's needs, and iron concentrations, as expected, are well below the maximum permissible levels.

Replacing Expensive "Imported" Surface Water with Local Groundwater

Fayetteville, Georgia

In the late 1980s, the City of Fayetteville, Georgia was purchasing its water from Fayette County which, in turn, was purchasing water from the City of Atlanta. That water was being piped over 70 miles, from Lake Lanier north to Atlanta, to Fayette County on the far southwest of Atlanta. While single-family residences on the Georgia Piedmont often have deep bedrock wells, it has been commonly perceived that successfully locating and developing sizeable bedrock wells in this region is risky. Changes over very small distances (in some cases, even less than a few feet) in one direction or another can easily mean the difference between success and failure in finding enough water. Today, thanks to the groundwater exploration and development program used by HSA, just five wells yield over 1.3 million gallons per day for Fayetteville. Furthermore, by reducing its purchases of bulk water from others and replacing it with local groundwater, the City is in the process of saving over 73 percent of the cost it was paying for imported, treated surface water.

Following the initial experience of successfully conducting its groundwater exploration and development program in Georgia, HSA has gone on to hone its tools, methods and exploration program for other Piedmont communities in developing their own groundwater resources. HSA has conducted its successful exploration and development program, not only in the complex Piedmont hydrogeologic setting, but in the Valley and Ridge, Blue Ridge Mountains and Coastal Plains regions, as well.

TOWN OF COLEBROOK, NEW HAMPSHIRE

Test drilling in Colebrook. New Hampshire.

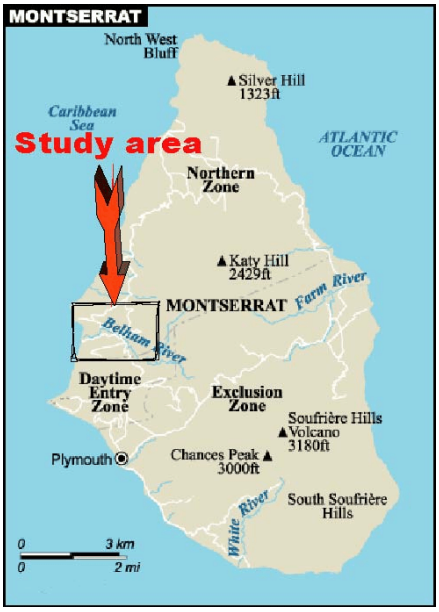
In November of 2002, the Town of Colebrook, through a competitive selection process, retained HSA to look for and develop a minimum of 400,000 gpd of new groundwater supply. Current HSA professional staff had the opportunity to revisit a Phase I study done by HSA in 1993 which identified Favorable Zones. HSA updated its initial work, using tools, techniques and data sources which were unavailable just ten years ago. Using the New Hampshire Department of Environmental Service's automated data base for contaminant threats and revisiting areas first looked at in 1993, HSA eliminated one Favorable Zone because a convenience store/gas station had been constructed there. HSA has also converted its Geographic Information System from AutoCad to ArcView software resulting in a more sophisticated and flexible system of mapping and visualizing in three dimensions. Using previously unavailable Digital Elevation Models (DEMs) in conjunction with updated Phase I information, HSA found it necessary to modify another one of its Favorable Zones. Likewise, having the good fortune of conducting field work in a severe drought, HSA revised its recharge capabilities for one Favorable Zone which modified its ranking. Searching primarily but not exclusively for a sand-and-gravel source, HSA employed several geophysical survey techniques. Gravimetric surveys were conducted to profile the bedrock topography in an attempt to identify the thickest overburden deposits and the axis of structural troughs (associated with fractured bedrock aquifers) that may exist in the underlying bedrock. Ground-penetrating radar surveys were used to assess the nature of overburden deposits, up to approximately 60 to 80 feet in depth, to determine if the potential for developing a well in a sand-and-gravel aquifer exists. Electrical resistivity methods were used to assess the nature of the overburden deposits at depths greater than 60 to 80 feet (as wells elsewhere in the Connecticut River Valley have shown that bedrock can lie over 150 feet beneath the overburden). In addition, electromagnetic and magnetic surveys were used to assess the potential for developing fractured bedrock aquifers that are suspected to underlie certain areas. Combining the results of the analysis of the geophysical survey data with all previous work, HSA identified four (4) test well sites, each with the object of developing a sand-and-gravel source, with three of those four also offering potential for a bedrock well beneath the unconsolidated material. Test wells were drilled, and permeable, coarse-grained materials were encountered in all of them. Preliminary flow testing and water quality testing have been carried out on the most productive well. Results of

this work show that individual wells possess the capacity to provide over 575,000 gallons per day. Water quality appears good, and the presence of the thick clay layer over the water-bearing zone means that the aquifer is unusually well protected from contamination, while still being well situated to receive ample recharge from a broad area. HydroSource continues to work with the Town of Colebrook to install and test production wells at the site, and to obtain NHDES approval for the new public water supply.

GROUNDWATER EXPLORATION AND PRODUCTION WELL DEVELOPMENT, MONTSERRAT, WEST INDIES -- 2004

Montserrat, a 40-square mile island in the Caribbean's Lesser Antilles, experienced a major volcanic eruption in 1995 and the volcano has continued to be active ever since. Almost two-thirds of the island was evacuated and the main town of Plymouth was abandoned, having been buried with up to 30 feet of ash. In recent years, residents have been returning to the island and a cleanup effort in Plymouth is ongoing. The Soufriere Hills volcano destroyed a large portion of the island's water supply. Under a contract with the Montserrat Water Authority, HydroSource Associates was contracted to employ its water exploration technologies to locate and develop a minimum of 240,000 gallons per day (gpd) of potable groundwater in an area that was protected from the ongoing volcanic activity.

Drilling in the shadow of the Soufriere Hills Volcano



HSA conducted controlled-source audio-frequency magneto-telluric (CSAMT) and gravimetric surveys which indicated a possible aquifer from 150 to over 700 feet deep on the northern edge of Belham Valley outside the direct influence of the active volcano. A Foremost Dual Rotary DR-24 drilling rig was used to drill test wells and production wells. This rig was used due to the difficulty in advancing well bores through the local pyroclastic sediments without the use of drilling mud. The drilling methods previously used by others in Montserrat involved the injection of thick drilling fluids (mud) to stabilize the borehole. Drawbacks from using drilling fluids include poor rock sample identification and the inability to measure water quality and production quantity accurately. In addition, clogging

of formation void spaces with drilling mud can reduce production yields and the technique often requires more well development time and increased cost.

Even after the conduct of 13 previous studies by others and the drilling of 80 test boreholes over the last 40 years, the groundwater potential of volcaniclastic aquifers on Montserrat was not well understood. A site-specific geologic framework guided the HSA exploration program and existing exposures of volcaniclastic deposits were used as the basis for interpreting geophysical and test drilling results. Two production wells capable of sustainably producing more than 1,000,000 gallons per day each were developed, providing the Montserrat Water Authority with groundwater for current demand and future growth. This project was completed in three months.

Fresh, potable water for the returning residents of Montserrat

TRINIDAD, WEST INDIES
Water Development Success

HydroSource Associates designed, coordinated and carried out a project for the Water and Sewerage Authority (WASA) of Trinidad and Tobago that had a goal of locating 15 million gallons per day of new fresh groundwater sources for Trinidad and the development of a new "Hydrogeologic Assessment" report and maps of its groundwater resources. The results demonstrated that the Island had over 200 million gallons per day of fresh, sustainable groundwater supplies available over that which was already being withdrawn. This assessment involved the analysis of numerous electric logs, seismic profiles, and water well completion reports which were integrated in a GIS database from which hydrogeologic maps were generated as part of the final report. The project team created the most detailed geologic maps available to use as a base for the island-wide hydrogeological assessment, including hundreds of high resolution images depicting aquifer boundaries, recharge amounts, and location of existing hydrogeological and geophysical data. In the second part of the project, the HSA team developed over 15 million imperial gallons per day of new fresh water supplies over a 20-month period, with wells tapping both bedrock and alluvial aquifers that were not known to exist prior to HSA's involvement. Many of the individual wells located produce yields of one to two million gallons per day each. The successful development of these supplies was due in large part to a geophysical and well drilling program that used technologies never never before applied in Trinidad, which included controlled source audio-magnetotelluric geophysical surveys (CSAMT) and dual rotary well installation methods.

ISLAND OF TOBAGO, WEST INDIES
Major New Water Sources

HydroSource Associates, Inc. designed, coordinated and carried out a project that had an initial goal of developing 2.2 million gallons per day (mgd) of new, fresh groundwater sources on the island of Tobago. The initial client was the Water and Sewerage Authority (WASA) of Trinidad and Tobago. Prior to this undertaking, the total yield of groundwater sources in Tobago was less than 100,000 gallons per day. HSA identified several areas it deemed favorable for the development of groundwater, taking into consideration those specific places needing water. Favorable Zones included potential crystalline and carbonate bedrock sources and alluvial aquifers. HSA personnel assembled and reviewed existing geologic, hydrologic, pedologic, and climatological information; analyzed satellite imagery for geologic structure; conducted in-field geologic mapping to ground truth mapped structural features of interest; conducted well-siting geophysical surveys; and subsequently selected and located sites for test well installation. HSA directed well drilling and developed six (6) high-yield bedrock production wells which were each tested and demonstrated indefinite sustainability. The client was provided with a documented well/aquifer management program based on a comprehensive evaluation of the aquifer, its sustainable yield and the local environmental conditions; a three-dimensional cross section of the geologic setting of the well and aquifer; a well construction log; results of geophysical surveys; long-term constant rate aquifer pumping test results; and water chemical quality data. The 2.2 mgd of new capacity was achieved in a single year. Based on these results, HAS was then contracted by the Tobago House of Assembly to develop an additional 2.2 mgd of fresh water supply. Following the same steps, the first bedrock well located, drilled and developed yielded 1.5 mgd. The final goal was quickly achieved.