A. DESCRIPTION OF PROPOSED ACTION

1. Introduction

Glen Cove Hospital (the Hospital), part of the North Shore-LIJ Health System is a private 265 bed hospital located at 101 St. Andrews Lane in the City of Glen Cove, Nassau County, New York. The Hospital currently consists of 11 buildings on approximately 10 acres of land bordered by St. Andrews Lane to the north, Trubee Place to the west, Dosoris Way to the south and Walnut Road to the east. Residential development surrounds the Hospital campus.

The surface elevations at the site range from approximately 150 feet above mean sea level (AMSL) near the site's northeast corner at St. Andrews Lane to 120 feet AMSL at the site's southwest corner near Dosoris Way. The majority of the northern portion of the site is gently sloping with steep reliefs in grade situated toward the south portion of the site. Please see Figure 1 in the Figures section of this report for a site location map.

The Hospital will be upgrading the facility's two existing geothermal well systems as described in this report. Both systems are used solely for cooling and air conditioning, have been in operation since the 1960s, and are at or otherwise nearing the end of their useful life cycle.

P.W. Grosser Consulting (PWGC) has evaluated the condition of the ground loop components of the existing systems comprised of the wells, water main piping, valves and supply well pump motors. Lizardos Engineering Associates (LEA), working in conjunction with PWGC, has evaluated the mechanical components of each system, comprised of the chiller unit replacement at Building G and associated condenser water pumps and valving, and installation of new plate and frame heat exchangers (PFHE's), which are not currently installed. The electrical and controls replacements and upgrades have been evaluated by both PWGC and LEA. The replacement systems described herein were designed by the firm responsible for its respective components.

In addition to the Long Island Well Permit application submitted in conjunction with this report, a drilling permit application has been submitted to NYSDEC Division of Mineral Resources for the two proposed Lloyd system diffusion wells that will be installed to depths greater than 500 feet bgs.

2. Geothermal Well System Description

Two (2) independent open-loop geothermal well systems exist at the Hospital and have been in operation for cooling and air conditioning purposes since their installation during the 1960s. The supply well of the first system is screened in the Magothy aquifer, so this geothermal well system is referred to in this report as the "***Magothy system***." The supply well of the second system is screened in the Lloyd aquifer, so this geothermal well system is referred to in this report as the "***Lloyd system***." Each system typically operates for a total of approximately 3,000 hours per year between May and September. Figure 2 shows the locations of the existing and proposed geothermal well systems that are described in this report.

a. Water Supply System History

Prior to utilizing the City of Glen Cove's public water supply system for potable use, the Hospital operated and maintained its own supply well (well N5994). This well was placed into service in 1957 and its use as the Hospital's primary potable water source was discontinued around 1994/95 when the Hospital switched over to full time public water. The well, which was 226' deep with 12" diameter screen and a pumping capacity of 750 gpm was abandoned in 2003.

The existing Magothy geothermal system has been in operation since its installation in 1963 and the existing Lloyd system since the completion of its installation in 1969. Each system underwent emergency rehabilitation in May 2011 to extend their useful lives until the replacement systems proposed in this report can be installed. The existing Lloyd system diffusion well that is screened in the Lloyd aquifer was rehabilitated. The existing 60 HP oil-lubricated vertical turbine pump in the Lloyd supply well was replaced with a new 75 HP water-lubricated vertical turbine pump. The existing Magothy system supply well that is screened in the Magothy aquifer was brushed and bailed and a new 20 HP submersible pump was installed to replace the existing 20 HP submersible pump.

b. Population Served and Per Capita Use

This section is not applicable as the proposed geothermal wells are to supply water for cooling and air conditioning purposes only.

c. Past Pumpage

The existing geothermal well systems are typically in use when outdoor ambient temperatures exceed 55°F (generally May through September) and are estimated to be in operation for 3,000 hours per year. The Magothy system operates at 180 GPM which equates to an estimated annual pumping/recharging of 32,400,000 gallons. The Lloyd system operates at 650 GPM which equates to an estimated annual pumping/recharging of 117,000,000 gallons. The total combined maximum pumping/recharging rate is 830 GPM, which equates to an estimated annual pumping/recharging of 149,400,000 gallons.

d. Projected Demand

No further expansions are planned for the Hospital and the proposed geothermal systems are expected to operate at the same flow rates as the existing geothermal systems. The projected demand is based on the past pumpage, which is estimated to be 149,400,000 gallons per year.

e. Existing Facilities

The Lloyd system and the Magothy system are completely independent of one another and provide cooling for different parts of the Hospital. As a result, the two systems are discussed separately in this section.

i. Existing Magothy System

The existing Magothy system is comprised of one (1) supply well installed to a depth of 193 feet bgs and screened in the Magothy aquifer (well no. N7280), and one (1) diffusion well installed to a depth of 126 feet bgs and screened in the upper glacial aquifer (well no. N7403D). The wells for this system are located within an open courtyard near the center of the Hospital's campus. Refer to Figure 3 for a partial site plan that shows the layout of the existing Magothy system, as well as the proposed Magothy system described later in this report.

Table 1 in the Table section of the report summarizes the existing geothermal wells installed at the Hospital.

The existing Magothy system supply well has an 8" diameter, 20 foot long stainless steel screen set between 173 and 193 feet bgs, and a 20 HP, 200 V, 3-phase submersible pump installed within a 4' x 8' below-grade vault. This system operates at 180 GPM which equates to an estimated annual pumping/recharging of 32,400,000 gallons.

The existing Magothy system diffusion well has a 6" diameter, 26 foot long stainless steel screen set between 100 and 126 feet bgs. The wellhead is accessible from a 20-inch diameter cast cover installed at grade. The well was slip-lined in 2003 with 4" channel pack screen.

The mechanical equipment for the existing Magothy system is located within the basement of South Building G mechanical equipment room (South MER). The mechanical equipment includes the following:

- One (1) 60-ton and one (1) 40-ton water-cooled chiller that each use R-22 as refrigerant;
- Two (2) 7.5 HP end-suction pumps; and
- One (1) 5 HP end-suction pump that serves the 60-ton chiller.

Groundwater is pumped from the supply well directly through the existing chillers, exchanges heat energy, and is conveyed to the diffusion wells and back into the aquifer.

The electric service for the existing Magothy system is provided by switchgear located in the first floor of Building G. The switchgear is rated for 1600 A, 277/480 V and provides power to the 60-ton chiller via a 200 A fused disconnect switch. There is also a local 200 A fused disconnect switch located in the basement level of the South MER that serves the unit. The 40-ton chiller is fed from a tap located in a pull box in the basement level of the South MER. Additionally, there is a local 200 A fused disconnect switch serving the unit. The two (2) 7.5 HP end-suction pumps and one (1) 5 HP end-suction pump are currently powered via an electric panel, which is rated for 200 A, 120/208 V.

ii. Existing Lloyd System

The existing Lloyd system is comprised of one (1) supply well installed to a depth of 420 feet bgs and screened in the Lloyd aquifer (well no. N8343), and three (3) diffusion wells installed to varying depths (well nos. N8392, N8393D and N8394D) (see Table 1). Two of the existing Lloyd system diffusion wells are installed to a depth of 125 feet bgs and screened in the upper glacial aquifer, while the third well is installed to a depth of 580 feet bgs and screened in the Lloyd aquifer.

The Lloyd system wells are located on the north side of the property, near Building C. The supply well is located in a central room within that Hospital's Emergency Department. This well was originally located in an underground vault outside the building, but the Emergency Department was expanded and the building was constructed over the well. Refer to Figure 4 for a partial site plan that shows the layout of the existing Lloyd system, as well as the proposed Lloyd system described later in this report. See Table 2 for the construction details of the wells that comprise the existing Lloyd system.

The existing Lloyd supply well has a 12" diameter, 40 foot long stainless steel screen set between 380 and 420 feet bgs, and a 75 HP, 208 V, 3-phase, water-lubricated vertical turbine pump. Access to this well is limited to a 2-foot square service door located in a storage room or via a roof hatch directly above the well head. This system operates at 650 GPM which equates to an estimated annual pumping/recharging of 117,000,000 gallons.

The three existing Lloyd diffusion wells have 8" diameter stainless steel screens. The two wells screened in the upper glacial aquifer have 51 foot long screened intervals set between 74 and 125 feet bgs. The diffusion well screened in the Lloyd aquifer has a 63 foot long screen set between 517 and 580 feet bgs. All three diffusion wells are located within a landscaped area along the northern property line and are accessible from 20-inch diameter steel covers installed at grade.

At the time of a recent May 2011 video log of the existing Lloyd supply well it was observed that the well casing is not installed plumb and there was a significant amount of sediment accumulation within the well screen at the bottom of the well. It was estimated that less than 10 feet of the existing 40-foot well screen was exposed to enable water inflow from the aquifer into the well. The remaining 30 feet of the well screen was filled with sediment attributed to deterioration of the steel well casing as it corrodes and subsequently falls to the bottom of the well.

It was concluded by PWGC that the misalignment of well casing was causing frictional stresses on the line shaft of vertical pump that contributed to overheating of the 60 HP well pump. As a result, the pump motor was upgraded this year with installation of a 75 HP, 208 V, 3-phase water-lubricated vertical turbine pump motor.

The mechanical equipment for the existing Lloyd system is located within the North Mechanical Equipment Room (North MER), which is in the basement of the Hospital's Emergency Department at the north side of the Hospital. The mechanical equipment includes the following:

- One (1) 475-ton and one (1) 275-ton water-cooled chiller that each use Freon 134A as refrigerant; and
- Two (2) 40 HP horizontal split-case chilled water pumps.

Groundwater is pumped from the supply well directly through the existing chillers, exchanges heat energy, and is conveyed to the diffusion wells and back into the aquifer.

The electric service for the Lloyd system is provided by switchgear located in the North MER. There is a 2500 A, 277/480 V switchgear that is not heavily loaded (a maximum demand reading of 987 A was recorded on 6/8/2011) and was found to have sufficient spare breakers or spaces to serve future loads.

f. Projected Service Life of Existing Facilities

The typical design life for a geothermal well of the type that exists at the Hospital is 50 years. The wells that comprise the Magothy system are 48 years old and the wells that comprise the Lloyd system are between 42 and 44 years old, meaning they are nearing the end of their expected service life. In addition to corrosion inside the wells and the need for their rehabilitation or replacement, the piping, mechanical and electrical equipment is in need of an upgrade. Most of the piping is welded steel, which is known to be rusting. The two chillers in the Magothy system use R-22 as refrigerant, which is scheduled to be phased out by 2020. In general, both existing geothermal systems have no flow metering, limited pressure and temperature gauges, no system operation monitoring or feedback and a basic manual start switch to engage supply well pumps either on or off. Both the Lloyd and Magothy geothermal well systems at the Hospital are controlled manually and when a request for cooling or air conditioning is made to the facilities management department, the supply wells are started and run continuously until cooling is no longer needed, at which time the supply wells are then manually shut down.

Based on the rapidly deteriorating condition of the wells and pipes, the use of refrigerant that is soon to be phased out, and the lack of monitoring or controls on the system, the projected remaining service life of the existing facilities is minimal.

g. Existing Water Quality in Geothermal System Supply Wells

Groundwater quality in the aquifers beneath the Hospital is excellent. The Hospital operated its own potable supply well for nearly 40 years, and switched to public supply in 1994/95 only for convenience and not due to degraded groundwater quality. Copies of recent laboratory analyses are included in Appendix A. The analytical data presented indicate that the groundwater at the site is not contaminated.

h. Largest Water Users in System

This section is not applicable to the geothermal well systems described in this report.

3. Project Description

The proposed plan includes the complete abandonment of the existing Magothy system and a mixture of rehabilitation and replacement of the existing Lloyd system. Both existing Magothy wells will be abandoned and replaced by one (1) supply well and two (2) diffusion wells screened in the Magothy Aquifer. The existing Lloyd supply well will be rehabilitated to extend its useful life and the three existing Lloyd diffusion wells will be replaced by two (2) proposed diffusion wells screened in the Lloyd Aquifer. All water main piping, valves, supply well pumps and motors, chiller units, associated condenser water pumps, electrical equipment, and controls for the existing system will be removed and replaced by new and modern equipment except some cases where the existing equipment is still acceptable for use. In addition, modern PFHEs will be added to the system to prevent untreated well water from coming into contact with the rest of the mechanical equipment.

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The proposed system would operate similar to the existing geothermal systems with modern upgrades, as a once-through cooling, non-contact, non-consumptive-use open-loop system. Water would be passed through PFHEs, and then returned to the same aquifer at approximately the same depth it was removed from through the proposed diffusion wells. The water chemistry would not be altered by any chemical additives or treatments.

a. Proposed Well Size, Depth, Screened Interval, Capacity, Location, Distribution, Mechanical, Electrical, and Controls

i. Proposed Magothy System

The proposed Magothy supply well will be located at the north end of the open courtyard that the

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existing Magothy system is in. See Figure 3 for a partial site plan that shows the location of the Magothy system. The proposed Magothy supply well will have a 12-inch diameter casing and an 8-inch diameter screen. The well is proposed to be 245 feet deep with a 30-foot long Type 316L stainless steel screen at the interval from 210 to 245 feet bgs. The supply well will be capable of producing 180 GPM and will include a 20 HP, 460 V, 3-phase submersible pump and pitless adapter. See Table 3 for the details of the wells that comprise the proposed Magothy system.

The two (2) proposed Magothy diffusion wells will be located along the western side of the open courtyard that the existing Magothy system is in, south of the proposed Magothy supply well. The proposed Magothy diffusion wells will have 10-inch diameter casings and 8-inch diameter screens. The wells are proposed to be 185 feet deep with 60-foot long Type 316L stainless steel screens at the interval from 120 to 180 feet bgs. The proposed Magothy diffusion wells shall be fitted with pitless adapters that will be located in underground concrete vaults.

The submersible well pump shall discharge from the pitless adapter through a 4-inch diameter high-density polyethylene (HDPE) pipe. Once the pipe penetrates the building, it will transition to a 4-inch diameter cement-lined ductile iron pipe (CLDIP). The proposed Magothy supply well water pipes will connect to the source side of the new PFHE, which will be sized for 180 GPM with a heat transfer capacity of 1,569 MBH. On the load side of the PFHE, two (2) new 30-ton water-cooled scroll chiller modules will be installed along with all associated control points, control panel, and condenser and chilled water piping. One (1) new 7.5 HP end-suction chilled water pump and one (1) new 7.5 HP dual-temperature water heating water pump (primary and standby) will be installed. From the outlet of the plate and frame heat exchanger, 4-inch diameter CLDIP will carry the return well water to the building penetration. From there, 4-inch diameter HDPE piping will carry the well water to the two diffusion wells where it will be returned to the Magothy Aquifer.

ii. Proposed Lloyd System

The existing Lloyd supply well is proposed to be rehabilitated to extend its useful life and serve the proposed Lloyd system. The rehabilitation of the existing Lloyd supply well would include physical and mechanical cleaning of the well screen and casing, followed by chemical treatment if necessary. In addition, a new submersible well pump will be installed, the well's electric and control systems will be upgraded, and the supply well discharge piping and valves will be replaced. This well will be called the "rehabilitated Lloyd supply well" in this report.

The two (2) proposed Lloyd diffusion wells will be located within the landscaped area along the northern property line, near the three existing Lloyd diffusion wells. See Figure 4 for a partial site plan that shows the location of the proposed Lloyd system. The proposed Lloyd diffusion wells will have 12-inch diameter casings and 8-inch diameter screens. The Lloyd diffusion wells are proposed to be 570 feet deep with a 90-foot long Type 316L stainless steel screen at the interval from 475 to 565 feet bgs. The diffusion wells shall be fitted with pitless adapters that will be located in underground concrete vaults. See Table 4 for the details of the wells that comprise the proposed Lloyd system.

The submersible well pump shall discharge from the pitless adapter through an 8-inch high-density polyethylene (HDPE) pipe. Once the pipe penetrates the building, it will transition to an 8-inch diameter cement lined ductile iron pipe (CLDIP). The rehabilitated Lloyd supply well water pipes connect to the source side of the new plate and frame heat exchanger, which will be sized for 650 GPM with a heat transfer capacity of 9,975 MBH. The two (2) existing chillers will not be modified or replaced but two (2)

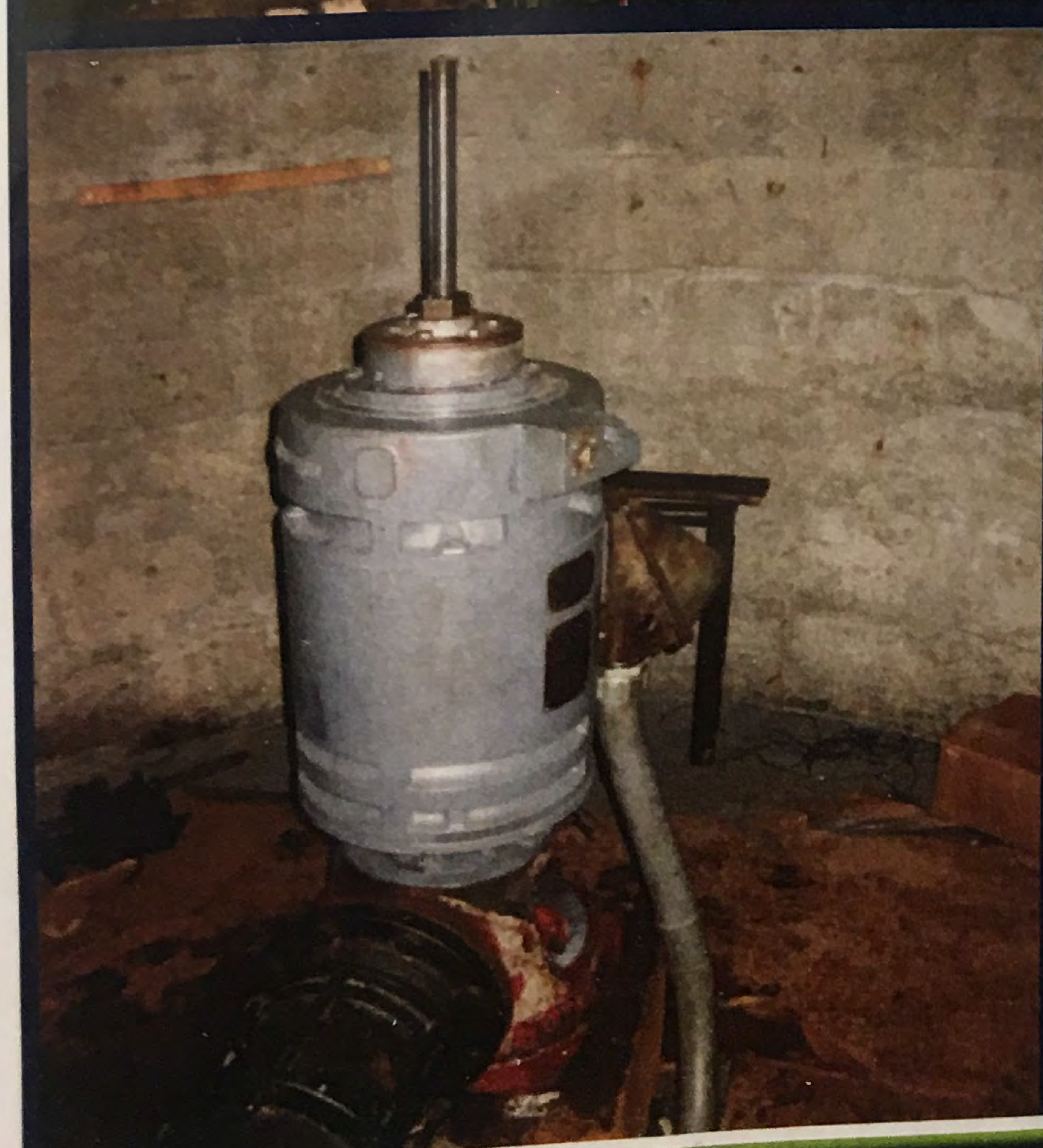
PWGC

Strategic Environmental Engineering Solutions

In association with Lizardos Engineering Associates, P.C.

North Shore LIJ At Glen Cove, New York Geothermal Systems Upgrades

Engineer's Report



North Shore LIJ

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101 St. Andrews Lane
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Magothy geothermal well systems at the Hospital are controlled manually.

The two Magothy chillers use R-22 as refrigerant, which is scheduled to be phased out by 2020. Both chillers must be replaced before 2020 to be in compliance with the new regulations.

B. ENVIRONMENTAL/HYDROGEOLOGIC SETTING

1. Proposed Screen Interval

The proposed screen intervals for the five proposed geothermal well systems and the rehabilitated Lloyd supply well are shown in Table 7. Each set of supply and diffusion wells will not have a vertical separation exceeding 50 feet in either direction and will be screened in the same aquifer unit in accordance with NYSDEC regulations. The existing Lloyd supply well that is to be rehabilitated dictates the allowable screen interval for the two proposed Lloyd diffusion wells. The three Magothy wells will be positioned to best take advantage of hydraulic characteristics of the Magothy Aquifer. The intervals presented in Table 7 may vary slightly from what will be installed depending on the geologic conditions encountered during drilling.

2. Aquifer Identification and Characteristics

The hydrogeologic setting of Long Island is well documented and consists of bedrock composed of schist and gneiss, which is overlain by a series of unconsolidated deposits. The bedrock is immediately overlain by the Raritan Formation, which consists of the Lloyd Aquifer and the Raritan Clay Member. Above the Raritan Formation is the Magothy Aquifer and finally the Upper Glacial Aquifer forms the uppermost layer. A hydrogeologic cross-section that shows the various layers is included as Figure 5. Characteristics of each aquifer are listed in Table 8. The average surface elevation at the Hospital is +140' AMSL.

At the proposed site, the surface of the bedrock occurs at an approximate depth of -430' AMSL or approximately 570' bgs (Swarzenski). Due to its crystalline nature, there is little or no groundwater flow in the bedrock.

Immediately overlying the bedrock is the Raritan formation, consisting of the Lloyd Aquifer and the Raritan Clay Member. The Lloyd Aquifer consists of discontinuous layers of gravel, sand, sandy and silty clay, and solid clay. The top of the Lloyd Aquifer at the site is approximately -245' AMSL or 385' bgs and is approximately 185 feet thick (Swarzenski). Nearby wells screened in the Lloyd Aquifer yield as much as 1,600 gpm and contain specific capacities ranging from 10 to 20 gpm per foot of drawdown (Swarzenski). The Raritan Clay appears to exist at the proposed site between approximately -105' AMSL and -245' AMSL, or between 245' bgs and 385' bgs (Swarzenski). The average thickness of the Raritan Clay in the vicinity of the site is approximately 140 feet. The Raritan Clay Member is relatively impermeable, effectively hydraulically isolating the Lloyd Aquifer from overlying aquifers. The Raritan Clay is solid and silty clay with few lenses of sand and gravel. The clay is lignite and pyrite and is gray, red or white in color.

Above the Raritan Clay lies the Magothy Aquifer. The Magothy Aquifer consists of fine to coarse sand of moderate to high permeability, with interbedded lenses of silt and clay of low permeability. According to the geologic log for well N8394-D, one of the existing Lloyd diffusion wells installed at the site, the top of the Magothy Aquifer is 125 feet bgs and extends to an approximate average depth of 245 feet bgs for a total thickness of 120 feet. The hydraulic conductivity of the Magothy Aquifer typically ranges from 270 to 870 gpd/sq.ft. (Swarzenski) in the horizontal direction and about 1/30 of the horizontal in the vertical direction (Franke and Cohen, 1972). The large disparity between the vertical and horizontal hydraulic conductivities indicates that water preferentially flows in the horizontal direction in this aquifer. Therefore, the Magothy Aquifer generally becomes more confined with depth.

The Upper Glacial Aquifer is the uppermost aquifer and is directly above the Magothy Aquifer. The Upper Glacial Aquifer is the water table aquifer at this location. This aquifer is comprised of medium to coarse sand and gravel with occasional thin lenses of fine sand and brown clay. The aquifer extends from the water table surface to the top of the Magothy Aquifer (125 feet bgs at the proposed site). The Upper Glacial Aquifer generally has greater water transmitting properties than the underlying Cretaceous age deposits with typical hydraulic conductivities ranging between 800 and 1,000 gpd/sq.ft. and may be as great as 2,000 gpd/sq.ft. (Swarzenski). The vertical conductivity of the Upper Glacial Aquifer is typically 1/10 of the horizontal in the area of the proposed site.

3. Interconnection with Surface Water Bodies

The nearest observed surface water bodies are listed in Table 9. It is anticipated that none of these surface water bodies will be affected by the proposed geothermal well systems due to the large distance from the site.

4. Proximity to Contaminant Sources

A review of environmental databases provided by EDR, Inc. found that several contaminant sources exist within one mile of the Hospital. Most sites within the one-mile radius represent registered underground storage tanks, RCRA generators, or very minor spills with no likelihood of an effect on the soil or groundwater. These sites are unlikely to have an impact on or be impacted by the geothermal system. A one-mile radius map provided by EDR, Inc. that depicts potential contaminant sources is presented in Figure 6. Table 10 contains specific data about each of the potential contaminant sources that may be of significance to the proposed geothermal systems.

5. Proximity to Contaminated Groundwater

A review of environmental databases provided by EDR, Inc. found that one source of contaminated water exists within one mile of the Hospital.

The source of contaminated water is the RonHill Cleaners Site, Site No. 1-30-071 on the NYS Registry of Inactive Hazardous Waste Sites. This site is located on Forest Avenue at the intersection with Bryce Avenue. RonHill Cleaners operated as a commercial dry cleaner since 1963 and is currently a Payless Shoe Source retail store. The hazardous waste disposed of at RonHill Cleaners was perchloroethylene (perc), a common chlorinated solvent utilized in the dry cleaning process. The site owner has operated a soil vapor extraction (SVE) system since 1996 in an effort to reduce perc concentrations in the soil.

According to the NYSDEC, groundwater samples confirm that perc contamination has reached the aquifer and says that the site presents a significant threat to the environment due to the continuing leaching of perc to the groundwater, the highly concentrated perc plume migrating from the site, and the proximity of the public supply well.

The NYSDEC is conducting ongoing investigations to further delineate the extent of contamination as part of a Remedial Investigation work plan.

6. Proximity to Other Wells

Significant wells located within a one mile radius of the Hospital are tabulated and presented in Table 11. The City of Glen Cove has five public municipal supply wells in three separate well fields located within one mile of the Hospital. The Seaman Avenue well field located approximately 1,400 feet north of the site contains three supply wells screened in the Upper Glacial Aquifer. This well field is currently contaminated with perchloroethylene from the RonHill Cleaners site. The wells are used only during high demand and are treated to remove all contaminants. A well field containing two deep supply wells each permitted for 1,400 gpm is located to the east south-east of the site approximately 4,200 feet away. The Locust Valley Water District also has one municipal supply well located approximately 3,800 east north-east of the site, screened in the Lloyd Aquifer and permitted for a withdrawal rate of 850 gpm.

7. Proximity to Saltwater Interface

The proposed geothermal systems are unlikely to affect the saltwater interface, please see Attachment A for details.

8. Results of Aquifer Pump Testing

The two existing on-site well systems installed in the Magothy Aquifer were pump-tested when they were constructed. Both systems were only tested for specific capacities and aquifer parameters were not determined at the times of the pumping tests. Based on the data collected from the pumping test of the abandoned potable supply well a specific capacity of 43.2 gpm/ft of drawdown was estimated. The geothermal well system screened in the Magothy had two brief pumping tests conducted, one for the supply well and one for the diffusion well. The geothermal supply well has an estimated specific capacity of 30.57 gpm/ft of drawdown while the diffusion well's specific capacity is estimated at between 11.25 and 16 gpm/ft drawdown based on injection and withdrawal tests respectively.

9. Aquifer Water Quality

As mentioned previously in Section A.1.g., site water quality is fairly well documented as the Hospital operated its own potable supply well for nearly 40 years. Copies of laboratory analyses are included in Appendix A. The analytical data presented indicate water of excellent quality.

10. Projected Water Quality and Yield

The geothermal cooling process involves using the groundwater as a heat sink. Thus water returned to the aquifer will have a higher temperature than what it was removed at.

Common problems often associated with warming and recharging water are bacterial growths, iron precipitation and scaling. These problems usually occur right at the well and are typically treated through chlorination, acid flushing, well surging and redevelopment. Based on the existing water quality data and the operation of two separate open loop geothermal well systems at the Hospital for nearly 50 years, serious water quality problems are not anticipated.

11. Drillers' Logs for On-site Wells

Drillers' logs for the six on-site wells are presented in Appendix D.

C. ENVIRONMENTAL/HYDROGEOLOGICAL IMPACTS

Please see Attachment A – Groundwater Modeling Report for full details related to environmental and hydrogeological impacts.

D. UNAVOIDABLE NEGATIVE ENVIRONMENTAL/HYDROGEOLOGICAL IMPACTS

The only apparent unavoidable impacts from the proposed geothermal well system appear to be localized water level changes and temperature changes. A cone of depression will occur around the two proposed supply wells while they are pumping. Mounding and localized seasonal warming will occur around the diffusion wells. Overall, on a regional and long term basis, there are no significant impacts expected.

E. ALTERNATIVES TO PROPOSED ACTION

Alternatives to the proposed action require the use of other methods for cooling the Hospital. The only other viable option is the use of cooling towers which is unfavorable for several reasons. First, the cooling towers would need to be constructed on-site, outdoors and above grade in an area that is surrounded by residential neighborhoods. The towers are not only unsightly but produce noise that can be heard beyond the property lines of the site. The towers also require sufficient space for operation and maintenance purposes. The Hospital site is well developed and if the units could not be reasonably located atop a roof, finding room for them would be difficult. Second, the geothermal cooling system has a better efficiency than cooling towers and makes using a ground source heat pump system much more appealing from a cost savings and environmentally appropriate standpoint. Less electric usage associated with the proposed project will save non-renewable fossil fuel resources. Finally, cooling towers use water treatment chemicals to prevent scaling, corrosion, and bacterial growth. These chemicals are routinely blown down or otherwise discharged to either the public sewer or on site directly to the environment.

It is our opinion that the use of geothermal wells is the best option to cool the hospital as the other viable option is potentially worse for the environment, unfavorable to the people that reside near the hospital, and more expensive to maintain.

F. MITIGATING MEASURES

The proposed action is environmentally sound and does not significantly impact the environment. The proposed geothermal well system will be fitted with flow meters, pressure sustaining valves, pressure gauges and thermometers in key locations to monitor/control pumping/recharging flow rates and groundwater temperatures. Modern plate-and-frame heat exchangers will be installed to prevent the well water from making contact with any other mechanical equipment or circulating condenser fluids that may contain chemical additives.

G. LIST OF RELATED STUDIES AND REFERENCES

1. Driscoll, F.G., "Groundwater and Wells", Johnson Screens, St. Paul, Minnesota, 1986.
2. Franke, O.L. and Cohen, P., "Regional Rates of Ground-Water Movement on Long Island, New York", Department of the Interior, U.S. Geological Survey Professional Paper 800-C, pages C271-C277, 1972.
3. Freeze, R.A. and Cherry, J.A., "Groundwater", Prentice Hall, Inc., Upper Saddle River, New Jersey, 1979.
4. Kavanaugh, S.P. and Rafferty, K., "Ground-Source Heat Pumps, Design of Geothermal Systems for Commercial and Institutional Buildings", American Society of Heating and Refrigerating and Air Conditioning Engineers, Inc., Atlanta, Georgia, 1997.
5. McClymonds, N.E. and Franke, O.L., "Water Transmitting Properties of Aquifers on Long Island, New York", Department of the Interior, U.S. Geological Survey Professional Paper 627-E, 1972.
6. Smolensky, D.A., Buxton, H.T. and Shernoff, P.K., "Hydrogeologic Framework of Long Island, New York", Department of the Interior, U.S. Geological Survey Hydroponic Investigations Atlas HA-709, 1989.
7. Swarzenski, W.V., "Hydrogeology of Northwestern Nassau and Northeastern Queens Counties Long Island, New York", Department of the Interior, U.S. Geological Survey Water Supply Paper 1657, 1963.

Table 1 - Well Details for Existing Magothy Geothermal System

Type	Capacity (GPM)	Aquifer	Depth	Screen Material	Screen Dia.	Screen Length	Screen Interval	Well No.	Year
Supply	180	Magothy	193′	S.S.	8"	20'	173'-193'	N7280	1963
Diffusion	-	Upper Glacial	126′	S.S.	*4″	26'	100'-126'	N7403D	1963

* Screen previously slip lined and reduced from installed 6″ diameter to 4″ diameter

Table 2 - Well Details for Existing Lloyd Geothermal System

Type	Capacity (GPM)	Screen Aquifer	Depth	Screen Material	Screen Dia.	Screen Length	Screen Interval	Well No.	Year
Supply	650	Lloyd	420′	S.S.	12"	40′	380'-420'	N8343	1967
Diffusion	-	Upper Glacial	125′	S.S.	8"	51′	74'-125'	N8393D	1969
Diffusion	-	Upper Glacial	125′	S.S.	8"	51′	74'-125'	N8392D	1969
Diffusion	-	Lloyd	580′	S.S.	8"	63′	517'-580'	N8394D	1969

Table 3 - Well Details for Proposed Magothy Geothermal System

Aquifer	Type	Capacity (GPM)	Depth	Casing Dia.	Screen Material	Screen Dia.	Screen Length	Screen Interval
Magothy	Supply	180	245′	12″	Type 316L S.S.	8″	30′	165′-195′
Magothy	Diffusion	-	185′	10″	Type 316L S.S.	8″	60′	120′-180′
Magothy	Diffusion	-	185′	10″	Type 316L S.S.	8″	60′	120′-180′

Table 8 - Characteristics of each Aquifer

Aquifer	Thickness	Interval	Elevation
Upper Glacial	125'	0' - 125'	140' - 15'
Magothy	120'	125' - 245'	15' - -105'
Raritan Clay	140'	245' - 385'	-105' - -245'
Lloyd	185'	385' - 570'	-245' - -430'
Bedrock	---	570'	-430'

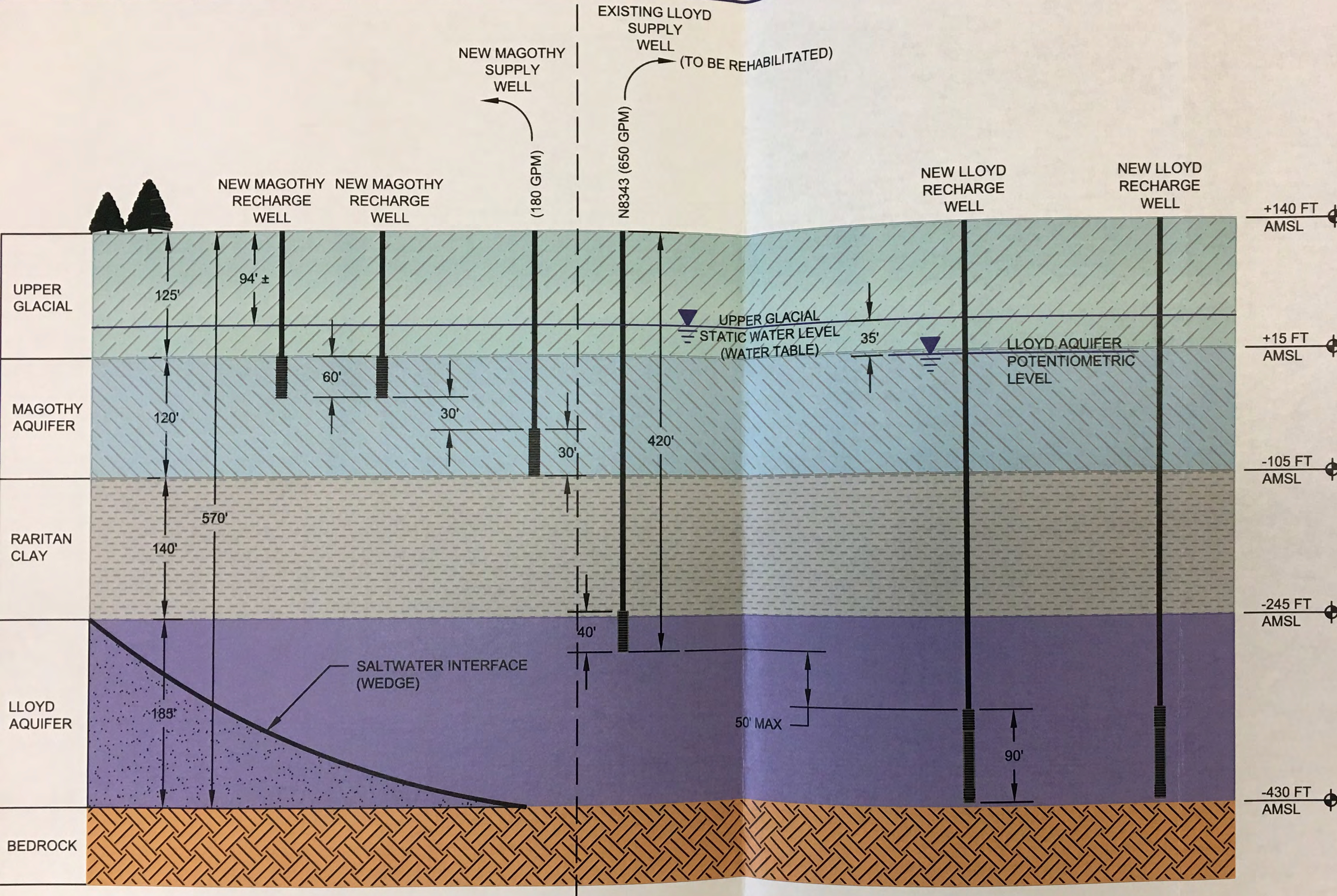
Table 9 - Surface Water Bodies

Surface Water Body	Distance From Site	Direction	Classification
Dosoris Pond	9,020 ft	North	Salt Water
West Pond	8,260 ft	North-West	Salt Water
Hempstead Bay	9,650 ft	West	Salt Water
Glen Cove Creek	4,990 ft	South-West	Brackish
Island Swamp Brook*	5,140 ft	North-North-East	Fresh Water

* Island Swamp Brook is considered a NYS Freshwater Wetlands.

Table 12 - Assumed Magothy Aquifer Parameters

Parameter	Symbol	Value
Horizontal Hydraulic Conductivity	Kx, Ky	390 gpd/ft2
Vertical Hydraulic Conductivity	Kz	10.92 gpd/ft2
Aquifer Thickness	b	120 ft
Transmissivity	T	46,800 gpd/ft
Storativity	S	0.0005
Porosity	n	0.26
Flow Direction	→	south-west
Groundwater Gradient	i	1/300



HYDROGEOLOGIC CROSS-SECTION PROPOSED GEOTHERMAL WELL SYSTEMS

NOT TO SCALE

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NORTH SHORE UNIVERSITY HOSPITA AT GLEN COVE

REVISION	DATE	INITIAL	COMMENTS

DRAWING INFORMATION

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HYDROGEOLOGIC CROSS-SECTION PROPOSED GEOTHERMAL WELL SYSTEMS

FIGURE NO 5

SHEET X OF X

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North Shore-LIJ Health System – Glen Cove Hospital

Open Loop Geothermal Well Systems Replacements: Groundwater Modeling Report

INTRODUCTION

North Shore-LIJ Health System at Glen Cove currently operates two separate open loop geothermal well systems. The larger of the two systems is a 650 gpm deep well system that consists of a single supply well drilled to a depth of 420 feet into the Lloyd Aquifer. The return wells associated with this system consist of three separate wells, a single deep well that is installed to a depth of 580 feet to the bottom of the Lloyd Aquifer and two shallow wells of 126 feet in depth installed in the Upper Glacial Aquifer. The smaller system is a 180 gpm system with a single supply well installed to a depth of 193 feet into the Magothy Aquifer and it has a single diffusion well associated with it that is 125 feet deep and installed in the Upper Glacial Aquifer.

The wells are aging and approaching the end of their design life cycles, thus the Hospital desires to replace them with new modern wells and make them compliant with current NYSDEC regulations which requires that supply and return wells be installed in the same aquifer with no more than 50 feet of vertical separation between the bottom of the more shallow well(s) and the top of the deeper well(s). Two separate systems will be maintained, a Lloyd Aquifer system of 650 gpm and a Magothy Aquifer system of 180 gpm. A groundwater modeling study was undertaken as part of the NYSDEC Long Island well permit application process to demonstrate that the two proposed open loop geothermal well systems will have negligible or insignificant effects on water levels in the aquifers into which they are being sought to be installed in.

MODEL AND SOFTWARE:

A finite difference method model was utilized to predict aquifer pumping responses under steady state conditions for both proposed geothermal systems. The modeling platform was run using the latest version of the USGS program MODFLOW. The software package used to run the model code was Groundwater Vistas Version 5.0 (GV5) by Environmental Simulations, Inc.

MODELING METHODOLOGY:

A three dimensional sub-regional numerical groundwater flow model was constructed to represent the northern part of the Town of Oyster Bay in the vicinity of Glen Cove, New York. The model was constructed using standard modeling methodology which consisted of:

- Identify modeling areal extents based on critical features and boundary conditions

- Formulate finite difference grid, import background maps, etc.
- Establish layers and zones based on area hydrogeology
- Adjust model geometry to approximate known conditions
- Input model properties such as aquifer parameters, boundary conditions, recharge, etc.
- Conduct initial model test runs
- Input calibration targets such as groundwater heads at known locations
- Calibrate the model using sensitivity analyses and calibration methods
- Refine model grid in major areas of interest
- Input pumping wells
- Conduct groundwater pumping scenarios using calibrated model
- Analyze and review modeling run results

1.0 Identify modeling areal extents based on critical features and boundary conditions

The model was built using a 3-d frame work by creating a grid or mesh of evenly spaced nodes in both the directions of the horizontal plane (x and y). Glen Cove Hospital was chosen to be at the center of the mesh and the mesh was extended outward 3 miles in both the north-south and east-west directions producing a 6 mile by 6 mile square area. A three-mile radius around the Hospital was selected because it captured key features of the area such as major surface water bodies, nearby municipal supply wells, USGS monitoring wells in the three principle aquifers of concern (the Upper Glacial, Magothy and Lloyd Aquifers) and was believed to be far enough away to reasonably establish sub-regional boundary conditions such as constant and general head boundaries. An 80 by 80 grid with nodes spaced 396 feet apart was selected and as mentioned above centered at the roughly 10 acre site of the Hospital (center coordinates of the model grid were 15,840 ft, 15,840 ft).

2.0 Formulate finite element difference grid, import background maps, etc.

A scaled background map was imported from AutoCAD as a DXF file to visually depict the outline of the Long Island coast in the model area as well as represent where the Hospital is positioned and the other important features such as monitoring wells. One-, two- and three-mile radius circles are shown as well, centered on the Hospital to further depict distance and sub-regional model extents (see Figure No. 1).

3.0 Establish layers and zones based on area hydrogeology

The model was divided into four layers and six zones to represent the main aquifers of the study area which included the following:

- Layer 1, Zone 1 = Upper Glacial Aquifer - unconfined
- Layer 2, Zone 1 = Upper Glacial Aquifer - unconfined
- Layer 2, Zone 2 = Magothy Aquifer - *unconfined
- Layer 3, Zone 3 = Raritan Clay Layer - confined
- Layer 3, Zone 6 = North Shore Confining Unit - confined
- Layer 4, Zone 4 = Lloyd Aquifer - confined
- Layer 4, Zone 5 = North Shore Aquifer - confined

*Magothy Aquifer in study area assumed to be hydraulically connected to the Upper Glacial Aquifer and was therefore modeled as an unconfined type of aquifer.

4.0 *Adjust model geometry to approximate known conditions*

Once the layers and zones were created the model then basically resembled a cube shape. The model geometry was then adjusted so that layers and zones had shapes, sizes and orientations that approximated actual known or inferred hydrogeological conditions. Layer top and bottom elevations were sloped and pitched to produce varying thicknesses and inclines or declines that reflected more realistic aquifer conditions. The documented complex nature of the geology and hydrogeology of the study area made this a particularly challenging and time consuming task. For instance, the Magothy Aquifer is known to be severely eroded in parts of the study area and its limits had to be carefully defined with sharp drop-offs in layer thickness at its edges. Other hydrogeologic units such as the North Shore Aquifer and the North Shore Confining Unit are poorly or only partially documented for the area and thus a significant amount of inference had to be applied to their extents, depths, orientations, etc.

5.0 *Input model properties such as aquifer parameters, boundary conditions, recharge, etc.*

With the model framework roughed out, the next step was to input numerical values for key parameters and establish a set of consistent units for the inputs that included:

- Horizontal hydraulic conductivity - $K_{x,y}$ (ft/day)
- Vertical hydraulic conductivity - K_z (ft/day)
- Storativity – S (unitless)
- Specific yield – S_y (unitless)
- Porosity – n (unitless)
- Recharge – R (ft/day)

Each zone of each layer of the model had each of the above parameters assigned to it based on published USGS values, with the exception of recharge. Recharge was only applied to layer one of the model where it is introduced. The table below is a summary of the model inputs based upon available published USGS values for the study area.

Table No. 1: Groundwater Model – Initial Input Parameter Values

Hydrogeological Unit	$K_{x,y}$ (ft/day)	K_z (ft/day)	S or S_y	n	*R (ft/day)
Upper Glacial Aquifer	270	27	0.1	0.3	0.005
Magothy Aquifer	50	0.5	0.0005	0.35	---
Raritan Clay	0.01	0.001	**0.00003	0.2	---
Lloyd Aquifer	40	4	0.0003	0.3	---
***North Shore Aquifer	30	3	0.0003	0.3	---
***North Shore Confining Unit	0.01	0.001	0.00003	0.3	---

*Recharge was only applied to Layer 1, Zone 1.

**No published USGS value for the storativity of the Raritan Clay in the study area could be found. Value is assumed based on clay and confined conditions.

***No published USGS values could be found for the North Shore Aquifer and North Shore Confining Unit. Values were assumed that approximated Lloyd Aquifer values for the North Shore Aquifer based on descriptions provided by USGS. Values were assumed that approximated the Raritan Clay for the North Shore Confining Unit based on descriptions provided by the USGS.

Boundary conditions were then assigned to the areas of the model to represent as close as possible the natural conditions of the study area. Boundary conditions are typically located at the edges of the model and are used to control heads and allow/compute the flux of water into and out of the model. Boundary conditions were assigned in layers 1 and 4 of the model. Layer 1, the north and west sides of the model, were assigned constant head boundaries with a head equal to 0 feet to represent the surface water bodies of the Long Island Sound and Hempstead Bay, each with surface elevations of mean sea level. Constant head boundaries do not change throughout model simulations and therefore usually represent infinite quantities of water, as would be the case for large surface water bodies such as these. The south and east sides of the layer were populated with general head boundaries to represent initial static groundwater heads of the local water table consistent with historical mean elevations for the model study area. General head boundary conditions were selected in these locations to allow groundwater flow into and out of the model under regional gradients.

Layer 4, the layer containing the Lloyd Aquifer in the model, was assigned boundary conditions on its east side, south side and lower (southern) half of its west side. General head boundaries were assigned in each of these locations to represent historic mean values of the potentiometric surface. No boundary conditions were assigned in Layers 2 and 3 as they were constrained by the boundary conditions of Layers 1 and 4.

6.0 *Conduct initial model test runs*

Initial test runs to generate graphical output were run once the model framework was constructed, the aquifer parameters and model inputs were entered and the boundary conditions established. This was done to identify problems such as insignificantly incorrect model geometry, input values, or boundary conditions. These initial uncalibrated model runs often generate groundwater head contours that are far from the actual or known conditions but at least allow the modeler to determine if the model is headed in the right direction as far as its initial development and where to look for major problems. Model simulation criteria such as selection of which solver package to use and when convergence is reached between consecutive iterations are selected at this point as well.

The initial test runs for the Glen Cove Hospital sub-regional model fared well. The model was able to converge and generate groundwater head contours that at least appeared to represent the general shape and orientation of the contours depicted on historical USGS maps for the study area. Though not completely accurate, and often off by tens of feet in certain layers, the model was able to produce output that from a starting point was usable and allowed for progression to the calibration phase of the model development.

7.0 *Input calibration targets such as groundwater heads at known locations*

The calibration process is often the most complex portion of groundwater modeling. The vast array of inputs, geometry and boundary conditions that can be adjusted to manipulate the model output can be significant and daunting. Additionally, the number of combinations of any of the above-mentioned variables can quickly become overwhelming even for experienced modelers. Groundwater Vistas has several means to simplify the process such as automated sensitivity analyses and automated calibration procedures.

Calibration was begun by importing targets into the Upper Glacial, Magothy and Lloyd Aquifers. These consisted of groundwater elevation data for several monitoring wells within the model grid or study area. The model was re-run and the calibration statics were posted (i.e., the difference between the target head and the predicted or modeled groundwater elevation, known as target residuals). This way, the precise differences between actual and modeled conditions could be quickly observed.

8.0 *Calibrate the model using sensitivity analyses and calibration methods*

Sensitivity analyses were performed to determine which model inputs would have the greatest influence on model output. Using the built-in sensitivity analysis features of GV5, it became obvious fairly quickly that the most sensitive model parameters were the horizontal and vertical conductivities for each of the zones. The highly sensitive nature of the model to these parameters became an issue because adjusting a hydraulic conductivity in one zone or layer of the model often had noticeable effects on groundwater heads in layers or zones that were believed to be hydraulically isolated from the area being analyzed. Thus as one layer began to appear to approach a well-calibrated state, other areas would go further out of calibration. The use of the automated calibration features of GV5 allowed the computer to run numerous simulations with multiple iterations that involved several of the vertical and horizontal conductivities at a time to generate the "best fit" or most calibrated model output. Unfortunately the automated procedure yielded several hydraulic conductivities substantially different from published USGS values and thus the automated procedure had to be reevaluated and combined with a more manual one. Table No. 2 below is a comparison of the initial USGS input values for hydraulic conductivities with the automated calibration values generated by the modeling software.

Table No. 2: Initial USGS Hydraulic Conductivities vs. Model Automated Calibration Values

Hydrogeological Unit	USGS Values		Automated Calibration Values	
	$K_{x,y}$ (ft/day)	K_z (ft/day)	$K_{x,y}$ (ft/day)	K_z (ft/day)
Upper Glacial Aquifer	270	27	14.85	27
Magothy Aquifer	50	0.5	168.43	0.5347
Raritan Clay	0.01	0.001	0.01	0.001
Lloyd Aquifer	40	4	8	1.70842e-5
North Shore Aquifer	30*	3*	4	0.00503561
North Shore Confining Unit	0.01*	0.001*	0.01	0.001

*No published USGS values could be found for the North Shore Aquifer and North Shore Confining Unit. Values were assumed that approximated Lloyd Aquifer values for the North Shore Aquifer based on descriptions provided by USGS. Values were assumed that approximated the Raritan Clay for the North Shore Confining Unit based on descriptions provided by the USGS.

The highlighted values in the above table indicate where the calibrated results deviated significantly from the initial input values. The calibrated values yielded target residuals that were for the most part within most modeling scenario accuracies (within a couple of feet) but they seemed totally inconsistent with known and well-studied values for the principal aquifers within the sub-regional model area. Thus a more refined and intensive approach was applied to reevaluate and recalibrate the model to more realistic hydraulic conductivity values while likely increasing the target residual values.

Another means of calibration that was used was checking known well specific capacities versus predicted model well drawdowns. This meant inputting pumping wells into the model as analytic elements. The two existing open loop geothermal supply wells for the Lloyd and Magothy geothermal systems at the Hospital were ideal candidates for this as data on the wells was readily available and they were both located at the heart of the model area. The model was recalibrated until specific capacity measurements at the two wells in separate aquifers approximated their original values (obtained from well driller NYSDEC well completion reports). The following two tables present the results of those efforts.

Table No. 3: Initial USGS Hydraulic Conductivities vs. Model Recalibration Values

Hydrogeological Unit	USGS Values		Recalibrated Values	
	$K_{x,y}$ (ft/day)	K_z (ft/day)	$K_{x,y}$ (ft/day)	K_z (ft/day)
Upper Glacial Aquifer	270	27	135	13.5
Magothy Aquifer	50	0.5	25	0.25
Raritan Clay	0.01	0.001	0.01	0.001
Lloyd Aquifer	40	4	20	2
North Shore Aquifer	30*	3*	15	1.5
North Shore Confining Unit	0.01*	0.001*	0.01	0.001

*No published USGS values could be found for the North Shore Aquifer and North Shore Confining Unit. Values were assumed that approximated Lloyd Aquifer values for the North Shore Aquifer based on descriptions provided by USGS. Values were assumed that approximated the Raritan Clay for the North Shore Confining Unit based on descriptions provided by the USGS.

Table No. 4: Specific Capacity Estimates and Calibration Process

Hydrogeological Unit	Actual Well S.C. (gpm/ft)	Uncalibrated Model S.C. (gpm/ft)	Auto Calibrated Model S.C. (gpm/ft)	Recalibrated Model S.C. (gpm/ft)
Magothy Supply Well	30.57	56.60	97.83	30.82
Lloyd Supply Well	15.79	30.22	6.18	16.01

The above results indicate that using hydraulic conductivity estimates for the Upper Glacial, Magothy and Lloyd Aquifers that were half of the published USGS values for the area, the model yielded specific capacity results that very nearly duplicated that of actual observed conditions. Though the groundwater contours did not precisely match the published USGS maps, they still reasonably approximated them when the recalibrated hydraulic conductivity values were input into the aquifer property database for the model. The major confidence gain that was obtained was the well pumping hydraulics near the well appeared to be accurately portrayed now. This was also verified using a calibration target monitoring well in the Lloyd Aquifer. The well is located approximately 1.5 miles southeast of the Hospital's existing Lloyd supply well (see **Figure No. 1**). Hydrographs obtained from the USGS website for the monitoring well reveal large seasonal potentiometric surface swings, upwards of 10 feet at the monitoring well (see Appendix A). When the Hospital pumping well begins the cooling season and withdraws water from the Lloyd and returns a significant portion of it to the Upper Glacial (via the two shallow diffusion wells associated with it) large potentiometric surface drawdowns are observed at the upgradient monitoring well. Though it is not possible to estimate what the total impact of the existing Lloyd supply well would have at that particular monitoring well (due to the effects of other local potential seasonal Lloyd Aquifer pumping wells) at least some influence would be expected due to the extremely confined nature of the aquifer. The table below presents the observed effects versus predicted.

Table No. 5: Potentiometric Surface Drawdowns at USGS Well N-11279.1

Monitoring Well	Observed (ft)	Uncalibrated Model (ft)	Auto Calibrated Model (ft)	Recalibrated Model (ft)
N-11279.1	13.58	3.21	13.46	4.45

The recalibrated model yields better results than the uncalibrated model, but as expected the auto-calibrated model produced the best results because it used the monitoring well as a calibration target and ended up generating hydraulic conductivities that were too far from published USGS values to seem realistic. Thus the recalibrated hydraulic conductivities again provided good results and were ultimately selected to base the modeling scenarios on.

9.0 *Refine model grid in major areas of interest*

The model grid or mesh was refined in the area of the Hospital once the model was calibrated to provide higher contour definition in the vicinity of the proposed geothermal supply and return wells. The grid spacings in the x and y plane were reduced from 396 feet to 49.5 feet right at the Hospital's property line and slightly beyond it on all four sides.

10.0 *Input pumping wells*

The proposed supply and return wells for both the Magothy and Lloyd Aquifer open loop geothermal systems were located and created spatially in the model. They were all installed in their respective layers and zones (Layer 2, Zone 2 for Magothy wells, Layer 4, Zone 4 for Lloyd wells) and screen top and bottom elevations were entered to vertically fixate the pumping and recharge zones in each well. Pumping and recharge rates were assigned to the wells in units consistent with the rest of the model (i.e., ft3/day). Water pumped from the model is denoted with a negative sign (-) and recharged water is denoted with a positive sign (+). The table below is a summary of the wells that were input into the model.

Table No. 6: Proposed Geothermal Well Input Summary

Well Name	Layer	Zone	Screen Length (ft)	Top of Screen Elev. (ft)	Bot. of Screen Elev. (ft)	Pumping Rate (ft^3/day)
Magothy Supply	2	2	30	-75	-105	-34,650
Magothy Diff 1	2	2	60	15	-45	+17,325
Magothy Diff 2	2	2	60	15	-45	+17,325
Lloyd Supply	4	4	40	-250	-290	-125,125
Lloyd Diff 1	4	4	80	-340	-420	+62,563
Lloyd Diff 2	4	4	80	-340	-420	+62,563

11.0 *Conduct groundwater pumping scenarios using calibrated model*

Several different model scenarios were run to predict the extents of influence of the two proposed open loop geothermal well systems at Glen Cove Hospital. Model output analyses were primarily focused on the Magothy and Lloyd Aquifers as that is where the two replacement geothermal systems are proposed to be installed. The modeling scenarios for each of the two aquifers included the following:

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- Static conditions – prior to the start of pumping.
- Pumping only – water was withdrawn from the aquifer but not returned.
- Pumping and recharging – full operation of the supply and return wells.

11.1 Lloyd Aquifer Modeling Scenarios

11.1.1 Static Conditions – Lloyd Aquifer

Static conditions in the Lloyd Aquifer were assumed to be during the non-pumping season (i.e., no irrigation wells or cooling wells would be expected to be in operation), or during the winter months of the year. The online USGS web based groundwater conditions maps were used as a comparison basis to check the model output against. The March 2006 potentiometric surface of the Lloyd Aquifer is presented in **Figure No. 2.** **Figure No. 3** is the recalibrated model output for a non-pumping and non-recharging scenario in Layer 4 of the model or the Lloyd Aquifer. A comparison between Figure Nos. 2 and 3 shows generally good agreement for groundwater flow direction and potentiometric heads. **Figure No. 3a** is the same graphical depiction of groundwater flow direction across the region through the Lloyd Aquifer as **Figure No. 3**. However, in **Figure No. 3a** a line of particles were released in the model at mid depth of the Lloyd Aquifer to map out flow paths and show a general northwest flow pattern. In cross section the particles also show an upward flow towards the Long Island Sound. **Figure No. 3b** represents a localized view of the Glen Cove Hospital site showing the Lloyd Aquifer geothermal well locations and static potentiometric head conditions across the Hospital campus.

11.1.2 Pumping Only – Lloyd Aquifer

The geothermal supply well in the Lloyd Aquifer (the existing Lloyd Aquifer geothermal supply well will be rehabilitated and reused with two new diffusion wells, refer to Long Well Permit Application Engineering and Hydrogeological Report for greater detail) will have a maximum permissible pumping rate of 650 gpm. **Figure No. 4** graphically presents predicted pumping conditions under a steady state withdrawal of 125,125 ft3/day (650 gpm) from the Lloyd Aquifer geothermal supply well without any recharge taking place. Under this scenario a large radius of influence is generated where noticeable drawdowns in the potentiometric surface are predicted beyond the three mile radius of the model grid (i.e., greater than 1 ft of drawdown over three miles away). This is completely expected due to the highly confined conditions of the Lloyd Aquifer. **Figure No. 4a** depicts the same line of particles as in **Figure No. 3a** and now there are significant notable differences. The pumping well generates a capture zone that is over 3.5 miles wide and significantly alters the local flow pattern in the study area. Again, this is expected due to the confined nature of the Lloyd Aquifer.

11.1.3 Pumping and Recharging – Lloyd Aquifer

Pumping and recharging 100% of the geothermal cooling return water to the Lloyd Aquifer significantly reduces and minimizes local and sub-regional effects to the potentiometric surface. **Figure No. 5** is a regional plan view of the model study area and shows primarily localized influence on the potentiometric surface right in the vicinity of the Hospital. Observable effects are limited to less than 1 mile and drawdowns or increases in the potentiometric surface are for the most part well below 1 ft. A side by side comparison of Figure Nos. 3 and 5 illustrate this graphically. Figure No. 5a presents the particle tracking again where a line of particles is released at mid depth in the Lloyd Aquifer and perpendicular to the original static flow conditions. Under the pumping and recharging scenario, Figure No. 5a visualizes how the sub-regional flow pattern is slightly altered as it passes by the geothermal wells when they are operating at steady state conditions. Groundwater to the southwest of the site is captured and drawn towards the supply well while groundwater to the northeast of the site is mildly deflected to the north due to the mounding created around the return wells. A local plan view is depicted in Figure No. 5b that represents 650 gpm of pumping and recharging into the Lloyd Aquifer in the immediate vicinity around the Hospital site. Figure No. 5c shows an expanded local plan view out to one mile from the center of the Hospital property. As can be seen from Figure Nos. 5b and 5c the drawdown and mounding of the potentiometric surface is heavily felt right at the Hospital where the supply well is predicted to experience a drawdown of 17.19 ft and the two diffusion wells No. 1 and No. 2 (No. 1 being closer to the supply well) experience predicted peak mounds of 10.72 ft and 12.35 ft respectively. Both the drawdown and mounding begin to drop off quickly away from the Hospital site due to the close proximity of the supply and return wells which serve to negate the effects of one another. **Figure Nos. 5d and 5e** present predicted flow paths via particle tracks. A ring of particles was released around the mid-point of the screen zones of the diffusion wells which are proposed to be installed in the lower half of the Lloyd Aquifer beneath the Hospital site. Due to the proximity of the wells a strong influence on one another is observed. Travel time analysis indicates that some of the recharged geothermal water could be returned to the supply well in less than 90 days.

11.2 Magothy Aquifer Modeling Scenarios

11.2.1 Static Conditions – Magothy Aquifer

The Magothy Aquifer in the study area is as previously mentioned severely eroded. **Figure No. 6,** which is a print out of the available online USGS maps for the Magothy Aquifer in the vicinity of Glen Cove, NY, shows the extents of the aquifer and how it is believed to be shaped. The Hospital site is situated just within the mapped limits of the aquifer. Limited water level data is available and the lack of groundwater contours for the Magothy Aquifer in the study area is clearly evident in **Figure No. 6. Figure No. 6a** is the same USGS map as Figure No. 6 but now the water table contours from the Upper Glacial Aquifer have been superimposed. The approximate congruency between the limited Magothy Aquifer groundwater contours and the Upper Glacial Aquifer infer that there is at least a local hydraulic interconnection between the two hydrogeologic units.

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