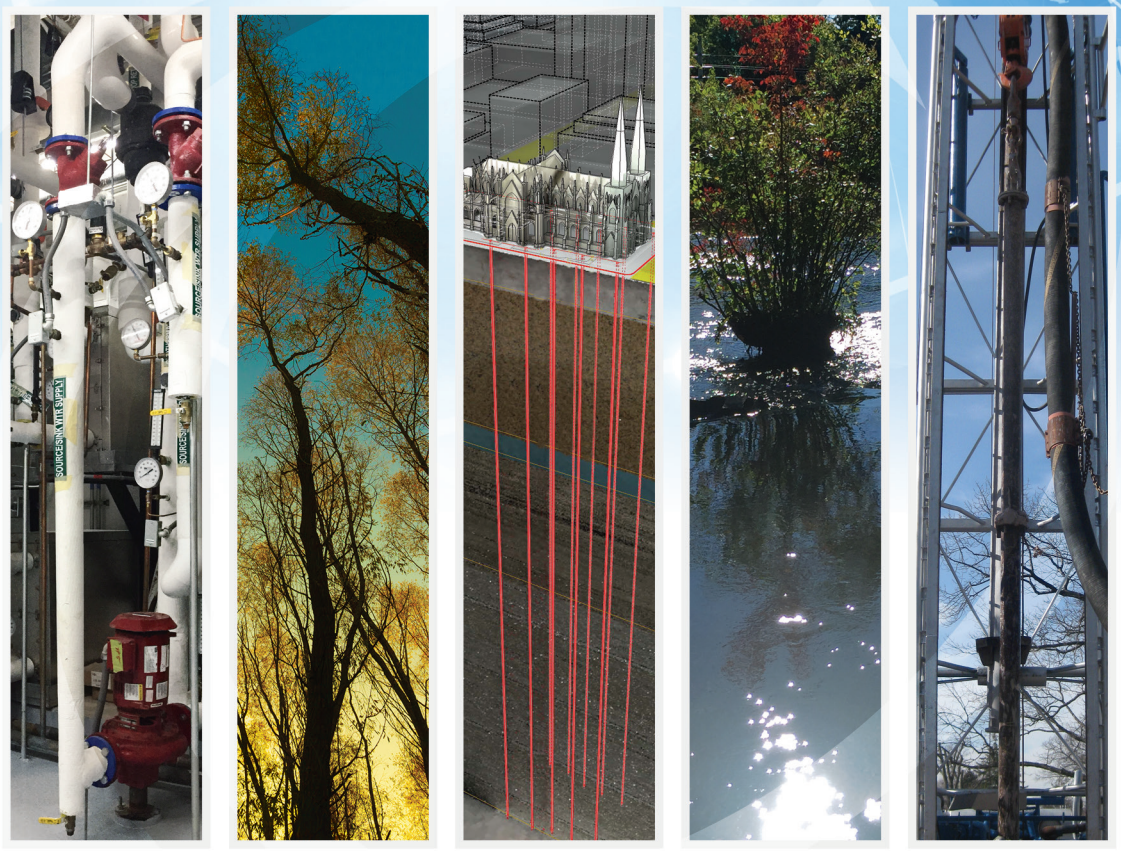


GEOTHERMAL HEAT PUMP SYSTEMS

CONTACT: Paul K. Boyce, PE, PG, President/CEO • paulb@pwgrosser.com
630 Johnson Avenue, Suite 7 • Bohemia, NY 11716
Phone: 631.589.6353 • Fax: 631.589.8705 • www.pwgrosser.com

PWGC
CLIENT DRIVEN SOLUTIONS

FIRM PROFILE

PWGC: CLIENT DRIVEN SOLUTIONS

MEET PWGC

PWGC was founded by Paul Grosser, PhD, PE, PG, a thought leader who recognized the need for a multi-disciplined engineering and environmental consulting firm that offered a diverse range of services to meet market demand regionally and nationally. Based in Bohemia, NY, PWGC has offices in New York City, Syracuse, Saratoga Springs and Connecticut.

PWGC serves the Northeastern United States and has established an industry recognized reputation for innovative problem solving and providing quality services to municipal, educational, private, public and federal clients. We are dedicated to providing quality products and timely services that result in practical solutions for its clients.

PWGC has a multi-disciplined staff of more than 70 professionals. Our strength lies with these licensed professional engineers, geologists and hydrogeologists, LEED accredited professionals and environmental compliance specialists, which gives PWGC a wealth of experience key to helping bring your project from idea to reality.

CHOOSE PWGC

Whether your objectives are planning, design, redevelopment, remediation or resiliency, PWGC's services are innovative and economical. PWGC is committed to client goals and our dynamic team of professionals provide innovation and flexibility to deliver customized solutions to projects regardless of size, complexity or duration.

THE PWGC DIFFERENCE

What sets us apart is our customized approach to each project, a dedicated, responsive team, our rapport with regulatory agencies and our exceptional project management. PWGCs assets that translate into additional value for you include the following:

- Strong working relationships with key regulatory sector players
- Specialists in regulatory requirements to facilitate quicker approvals
- Highly responsive to budget & time constraints to get your project on line faster
- Project and quality control monitoring to exceed your project needs
- More than 70 dedicated professionals to provide a wide array of services
- Strong understanding environmental compliance standards

Make PWGC's quality environmental consulting and engineering solutions work for you.

PWGC QUICK FACTS

Corporate

- Founded & Incorporated: 1990
- SAM/SBA Registered
- Small Business
- DUNS # 798730966
- Federal ID: 11-3612196

Offices

- Bohemia, NY
- New York, NY
- Saratoga Springs, NY
- Syracuse, NY
- Shelton, CT

Qualifications

- LICENSES - Engineer, Geologist, LSP, NC, NY, NJ, PA, MD, IN, NH, FL, WA
- LEED-AP
- Envision

Service Codes

NAICS

- 562910 Environmental Remediation
- 541330 Engineering
- 541620 Environmental Consulting
- 562998 Waste Management Services
- 541370 GIS Base Mapping
- 237130 Green Services

SIC

- 87489905 Environmental Consulting
- 8711 Engineering Services

SUMMARY LIST OF SERVICES

SEQRA Consulting and Planning Services

- Administration of the SEQRA Process
- Type II Opinion Letters
- Coordinated Review
- Environmental Assessment Forms
- Scoping Documents
- Environmental Impact Statements
- Determinations of Significance
- Findings Statements
- Notices and Assistance with Resolutions
- Land Use and Zoning Assessments

Environmental Services

- Contract Administration
- Petroleum & Chemical Spill Investigation & Remediation
- Remedial Alternative Assessment & Design
- Remedial Construction Management
- Property Transaction Services
  - Due Diligence, RI/FS, PCR
  - Brownfields Redevelopment—Investigation, Remediation, Program Management
  - Phase I, Phase II Environmental Site Assessments
  - NYC E-Designated Sites
  - NYC OER Program Management—Investigations, Remediation, Grant Application
  - Cost Estimating—Property Investigation & Remediation
- Environmental Audits—Assess Environmental Liability
- Environmental Assessment & Contaminant Source Evaluation
- Groundwater Investigation & Remediation
- Aquifer/Pumping Testing
- Risk-Based Approach Solutions
- Site Closure Reports
- UST/AST Management
- Air, Water, Soil & Soil Vapor Sampling/Monitoring Community Air Monitoring
- Environmental & Health Risk Assessment
- Radiological Investigation & Remediation Services
- Hazardous Waste Management
- Soil Management, Certified Clean Fill
- Storm Water Management
- Water Table Evaluation & Flood Mitigation
- Dewatering Design, Permitting & Compliance Sampling

Environmental Compliance/Management

- Air Quality—Title V Permitting, Air Emission Inventories, Tier II & TRI Reporting
- Articles XI & 12 Hazardous Materials Storage Compliance for Nassau & Suffolk Counties, NY
- Chemical/Petroleum Bulk Storage Tanks—Permitting, Audits, Regulatory/Environmental Compliance Management
- Facilities Contingency Plan Development/Management, including SPCC, SWPPP, FRP
- Compliance Review
- Regulatory Compliance Reporting
- FAR 139.321 Fire Safety Inspections
- Fuel Storage Facilities & Mobile Fuel Equipment

Industrial Hygiene

- Asbestos Inspections and Testing
- Indoor Air Quality
- Legionnaire Insoections
- Lead/Mold Testing and Remedial Plans
- Noise Surveys

Expert Counseling/Client Representation

- Expert Testimony, Support & Counsel

Wastewater/Water Supply

- Water Supply/Wastewater—Systems, Planning, Design
- Groundwater Modeling
- Site/System/Feasibility Evaluation, Planning & Technical Assistance
- Water Conservation Plan Development

Natural Resource Studies

- Wetlands Delineation, Permitting & Mitigation Design
- Threatened & Endangered Species Surveys
- Migratory Studies
- Ecological Studies
- Ecological Risk Assessments
- National Environmental Policy Act (NEPA) Studies
- Planning
- Watershed Analysis

Energy/Sustainability Solutions

- Geothermal System Feasibility Analysis, Design, Permitting & Construction Management
- Renewable Energy Design for Solar & Wind
- Carbon Footprint Analysis, Profile & Management
- Alternative Fueling Station Planning & Design, Equipment Specification, Construction Observation, Permitting, Compliance & Facility Commissioning for Compressed Natural Gas, Hydrogen, Biodiesel & Ethanol-85
- Building Due Diligence & Energy Studies
- LEED Administration & Sustainable Design Practices
- High Performance Sustainable Buildings
- Energy Conservation & Energy Recovery Alternatives
- MEP/High Efficiency Equipment Solutions
- Power Generation, Cogeneration & Fuel Cells
- Energy Modeling, Utility Rebate Programs & Tax Incentives
- Green Legislation & ARRA Stimulus Grants
- GIS Based Modeling for Wind, Solar & Carbon Footprint Analysis

Civil/General Engineering

- "Best Economic Alternatives" Evaluation
- Comprehensive Feasibility Studies
- Conservation Plan Development
- Construction Planning, Management, QA/QC
- Drainage Planning, Grading & Design
- Evaluation, Planning & Technical Assistance
- Facility Design & Condition Assessment
- Planning & Design
- Property Condition Report

Geographical Information Systems/Global Position Systems

- Data Collection & Conversion
- Infrastructure & Asset Management
- Wetlands & Endangered Species Delineation
- Digital Elevation Model Analysis
- Customized GIS Applications, GIS/CAD Integration
- Database Development, Conversions, Manual Digitizing
- Website Development
- GPS Field Data Collection & Post-Processing
- Remote Sensing & Image Processing

GEOTHERMAL DESIGN & CONSULTING SERVICES

Subsurface Conditions Due Diligence
- Published US Geological Survey geologic/ hydrogeologic data review
- Site-specific data review, e.g., environmental and geotechnical investigations
- PWGC in-house records review, nearby prior projects
- Consult with local drilling firms
- Proximity to water tunnels, major utilities/easements, rail/subway tunnels, etc.

Feasibility Study
- Evaluate ground coupling options – open loop wells, closed loops, standing column wells, ponds, energy piles and foundations, ATES and BTES
- Evaluate configurations – individual buildings, campus/district heating and cooling, integration with other renewables (PV, solar thermal, ice, CHP, etc.)
- Conceptual well and/or loop field layouts
- Potential site constraints and limitations, constructability
- Typical operation and maintenance
- Applicable permits, filings, and notifications
- Project logistics and scheduling
- Construction costs, economic and financial analysis
- Utility rebates and tax credits
- Field testing recommendations

Design
- Well/loop-side system design, coordination with project architect, MEP and other consultants
- Prepare coordinated construction documents
- Cost estimating support

Field-Testing Programs
- Arrange and implement field-testing programs
- “Piggyback” geothermal testing with geotechnical and environmental drilling programs
- Open loop test wells and pumping tests
- Groundwater sampling and testing
- Groundwater modeling
- Closed system test loop installation and ground thermal testing
- Data analysis and report preparation

Environmental Due Diligence
- Existing Phase I/II environmental reports review
- Order/review updated environmental database search report and Sanborn maps
- Potential for encountering contaminated groundwater
- Potential for contaminated drill spoils, i.e., disposal cost premiums

Filings and Notifications
- USEPA “Authorization by Rule”
- NYSDEC Division of Mineral Resources drilling permit
- NYSDEC Division of Water Long Island Well permit
- NYCDEP sewer discharge permit
- NYCDEP approval to drill near public water supply facilities (e.g., water tunnels)
- MTA, PANYNJ, LIRR, etc. approvals to drill in proximity to rail/subway lines
- NYCDOT Revocable Consent for sidewalk wells/loops
- NYCDOT sidewalk/street closing permits support

Construction Administration
- Identify qualified drilling contractors
- Coordinate pre-bid inspection
- Review/comment on bids, recommend contractor selection
- Review/comment on shop drawings
- Review/respond to RFI’s
- Review/prepare as-built drawings

Field Inspection during Construction
- Drilling/well and loop field construction inspection
- Document geologic/hydrogeologic conditions
- Monitor compliance with permit conditions
- Coordinate required field data reporting to agencies
- Coordinate/collect baseline groundwater samples and pump test (hydraulic) data
- Coordinate between mechanical engineer and drilling contractor
- Inspect borehole “drift” monitoring by specialty subcontractor
- Oversee/coordinate vibration and noise monitoring, if required
- Oversee/coordinate noise monitoring, if required
- System Installation/Final Engineering report

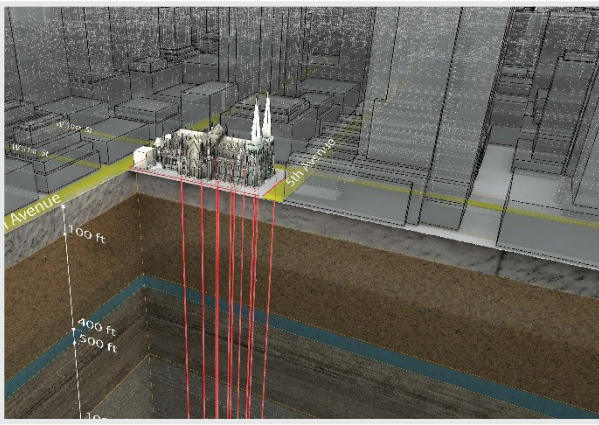
System Start-Up and Commissioning
- System charging, disinfection, start-up and balancing support
- Coordinate hydraulic and thermal capacity testing
- Well-side system commissioning
- Operation and Maintenance manual preparation and training

Operation and Maintenance
- Monitor system performance
- Troubleshoot operating systems
- Diagnose well problems and performance
- Develop system corrective actions and well rehabilitation programs

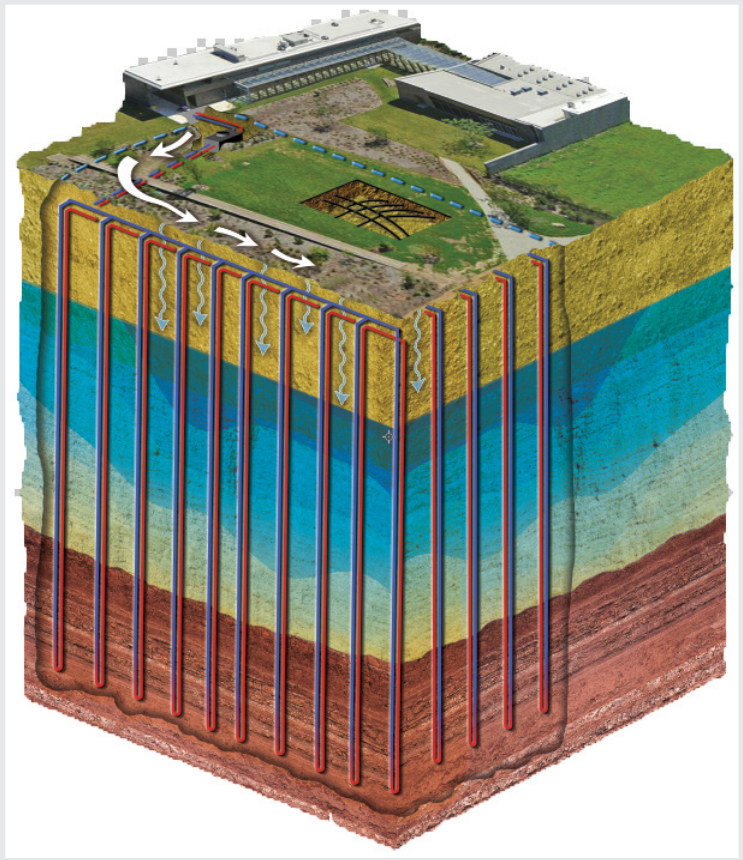
GEOTHERMAL SYSTEMS SUSTAINABLE TECHNOLOGY

INTRODUCTION TO GEOTHERMAL SYSTEMS

For more than 30 years, PWGC, an experienced environmental engineering firm, has specialized in the application of geothermal technology in the commercial, institutional, educational and high-end residential market segments. Founded by thought leader Paul W. Grosser, PhD., PE, PG, and Executive Chairman, PWGC has developed a well-honed approach to assessing and designing geothermal solutions for properties that benefit both the client and the environment.



Given the growing focus on environmental responsibility, geothermal technology is coming to the fore and represents one of PWGC's most important market segments. As a result, the firm's geothermal practice is led by the firm's senior and most experienced members, including President/CEO Paul Boyce, PE, PG, whose real world experience applying geothermal technologies gives PWGC the required perspective to deliver designs that can meet the most stringent development requirements. PWGC has designed and developed a wide variety of geothermal systems ranging in size from small commercial sites to campus-scale projects for the public and private sector.



What is a Geothermal Heat Pump ("GHP") System?

A GHP taps into the massive reservoir of thermal energy stored in the earth beneath us, derived predominantly from the sun, to efficiently heat and cool a building interior. A GHP consists of one or more geothermal (technically "ground source") heat pumps used in conjunction with a buried ground heat exchanger (loops or wells). This single mechanical system replaces the boilers and central air conditioning units of a conventional HVAC system.

Benefits of GHP Systems

Ground-source heat pump technology is an established, although often overlooked, HVAC option towards achieving greater energy efficiency and reducing our dependence on foreign oil. Buildings account for over 40 percent of the total energy used throughout the world, and the greatest portion of energy use in buildings is for heating and cooling. The United States Environmental Protection Agency and Department of Energy have concluded that a GHP is the most energy efficient, environmentally-clean, and easy to maintain heating and cooling system on the market today. Multiple studies have shown they have the lowest life-cycle cost of all other HVAC systems. With demonstrated high efficiencies come lower utility bills, on the order of 30 percent to more than 50 percent reduction over a conventional HVAC system, and elimination of on-site fossil fuel use and carbon emissions. Other benefits include elimination of noisy chillers, cooling towers and furnaces; reduced mechanical room size; supreme climate and dehumidification control; no visible outdoor equipment and contribution towards achieving points towards LEED certification.

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THE PWGC APPROACH AND LEADING INDUSTRY EXPERTISE

The PWGC Approach

PWGC recognizes that every development project has its own identity and each geothermal application is unique, depending on client objectives, site conditions and regulatory environments. Our approach to each assessment is based on extensive discourse with the client to ensure that each geothermal design will meet their heating and cooling objectives. A GHP may not be a good fit at every site and there are many things to consider. That is where PWGC comes in. Our services include timely upfront due diligence and feasibility analysis that allows our clients to make an informed decision whether or not to pursue a GHP system and, if so, what type of ground heat exchanger to use. PWGC's services include filings and planning, cost analysis, field-testing programs, modeling, design, construction management, system start-up, and developing maintenance programs.

PWGC an Industry Leader

PWGC's know-how has enabled us to be selected to work on a host of influential geothermal projects including St. Patrick's Cathedral HVAC retrofit to geothermal, Cornell University's flagship building, the Bloomberg Center, at its NYC Tech Campus on Roosevelt Island, and the NYC Department of Design and Construction Geothermal Heat Pump Manual.

PWGC believes that greater deployment of geothermal technology is necessary to help achieve the very aggressive goals for increased energy efficiency and reduced greenhouse gas emissions set by New York City, New York State and other states. To that end, PWGC has played a significant advocacy role at all levels of government. Some of the firm's activities and accomplishments include:

- Founding member, Long Island Geothermal Energy Organization (LI-GEO) established in 2012
- Charter member of the New York State Geothermal Energy Organization (NY-GEO) established in 2014
- Advisor to NYC City Council on drafting language for two geothermal bills to advance and facilitate use of geothermal technology in the city: Int. 694-A (registered as Local Law 32 of 2013) and Int. 609-A (Local Law 6 of 2016)
- Member, advisory committee to NYSERDA's Renewable Heating and Cooling department
- IGSPHA geothermal designer trainer (open loop systems)
- NYSERDA certified GSHP rebate contractor
- Contributor, NYSERDA Renewable Heating and Cooling Framework Document
- Co-author, NYC Geothermal Heat Pump System
- Co-consultant, NYC web-based Geothermal Feasibility Screening Tool
- Former committee member, joint ANSI/CSA C448 Series 16 North American GSHP Design and Installation Standards
- Member, Urban Green Advancing Electrification Advisory Committee (U.S. Green Building Council NYC Chapter)
- Author, uniform geothermal code promulgated by the Suffolk County Planning Commission.
- Advisor to various NYC agencies, including the Mayor's Office, Office of Sustainability and the NYC Economic Development Corporation, regarding the viability of greater deployment of geothermal technologies within the five boroughs.
- Author, the geothermal chapter for the Long Island Groundwater Resources Management Plan for Long Island's bi-County (Nassau and Suffolk Counties) Commission on Aquifer Protection (LICAP).

Our exceptional personnel and experience give PWGC's clients the foresight to make well-informed decisions to allow their projects to move from the realm of ideas to reality. PWGC is at the cutting edge of the growing geothermal industry, and can lead you through each step towards evaluating, choosing and implementing the technology at your project site.

PWGC GEOTHERMAL SYSTEM DESIGN AND CONSULTING AWARDS

- St. Patrick's Cathedral - 2018 AIA COTE (Committee on The Environment) Award
- St. Patrick's Cathedral - 2018 ACEC National Engineering Excellence Award - Honor Award
- St. Patrick's Cathedral - 2018 ACEC-NY Engineering Excellence Award - Diamond Award
- NYC Geothermal Screening Tool - 2018 ACEC-NY Engineering Excellence Award - Gold Award
- Weeksville Heritage Center - 2015 ACEC-NY Engineering Excellence Award - Platinum Award
- C.W. Post Winnick House - 2009 ACEC-NY Engineering Excellence Award - Platinum Award

PWGC CLIENT REFERENCES

Long Island Univerity, C.W. Post Campus Mr. Frank Casale - 516-299-3970 720 Northern Boulevard, Brookville, NY 11545	**Ross School** Mr. Richard Weiss- 631-907-5249 18 Goodfriend Drive East Hampton, NY 11937
Northwell Health - Glen Cove Hospital Mr. Alfonso Lafemina - 516-674-7657 101 St. Andrews Lane Glen Cove, NY 11542	**New York City Department of Design & Construction** Mr. Alex Posner - 718-391-1771 30-30 Thompson Avenue Long Island City, NY 11101
St. Patrick's Cathedral Mr. Jeffrey Murphy, FAIA - 212-768-7676 Murphy Burnham & Buttrick Architects 48 W 37th St #14 New York, NY 10018	**City of Cambridge Department of Public Works** Mr. Tim Boughner - 617-349-4823 147 Hampshire Street Cambridge, MA 02139

PWGC CLIENTS

Schools, Colleges and Universities
- Cornell University
- N.Y. Institute of Technology
- Bridgehampton, NY, Public School District
- Hewlett Public School District
- Adelphi University
- Hofstra University
- Fordham University
- Ross School
- Eastport/South Manor Public School District
- C.W. Post College
- Nassau County Community College
- Suffolk County Community College
- Pratt Institute
- Columbia University
- City University of New York
- University of Baltimore Law School

Institutions
- St. Patrick's Cathedral
- Brooklyn Children's Museum
- Queens Botanical Garden
- Brooklyn Botanic Gardens
- Staten Island Museum
- Staten Island Mental Health Society
- Weeksville Heritage Center
- The Bronx Zoo
- General Theological Seminary
- St. Joseph's Church, Brooklyn, NY
- St. Stanislaus Church, Brooklyn, NY
- Brooklyn Navy Yard Development Corp.
- Sterling and Francine Clark Art Institute
- Battery Park City Parks Conservancy
- Fort Ticonderoga

Architects
- JAG Architects
- Tod Williams Billie Tsien Architects
- Wiedersum Associates Architects
- Beyer Blinder Belle Architects & Planners
- Murphy Burnham & Buttrick Architects
- Stelle Architects
- Gluckman Mayner Architects
- Helpern Architects
- Robert A.M. Stern Architects
- SBLM Architects
- Morris Adjmi Architects
- Leroy Street Studio Architecture, P.C.
- COOKFOX Architects, LLP

Engineers and Contractors
- MEP Associates, Inc.
- AECOM
- Buro Hannold Engineers
- VHB Engineering, P.C.
- Bladykas Engineering, PC
- ads Engineers
- JB&B
- Burton Behrendt Smith
- WSP Flack & Kurtz
- Joseph R. Loring & Associates, Inc.
- Lizardos Mechanical & Electrical Engineering
- AKF Group LLC
- Altieri Sebor Wieber, LLC
- Horizon Engineering Associates LLP
- Kallen and Lemelson Consulting Engineers
- Metropolitan Building Consulting Group, PC
- Laszlo Bodack Engineer, P.C.
- Integrated HVAC Systems & Services Inc.
- The Louis Berger Group, Inc.
- Langan Engineering & Environmental Services, P.C.
- Mueller Associates, Inc.
- Greenman-Pedersen Inc.
- ZBF Geothermal, LLC

Developers/ CM's/Owners Reps
- L+M Developers
- Kulka Construction
- Hill International, Inc.
- Zubatkin Owner Representation, LLC
- Albanese Organization, Inc.
- Peter Moore Associates
- Belvedere Property Management
- HFZ Capital Group
- Two Trees Management
- The J Companies LLC

Commercial/Industrial
- Amneal Pharmaceuticals
- Google
- Ford Motor Company
- Consolidated Edison on NY
- Northwell Health
- Macy's
- Bridgewater Associates
- Glen Cove Hospital
- Standard Microsystems
- Citibank
- AIL Systems
- Underwriters Laboratories, Inc.
- Yonkers Housing Authority

Government/Municipalities
- NYC Mayor's Office of Sustainability
- NYS Environmental Research & Development Agency
- Dutch Consulate of New York City
- Town of Brookhaven Parks Department, NY
- Suffolk County Department of Public Works
- Fire Department of New York City
- City of Cambridge, MA, Department of Public Works
- Town of Babylon, NY
- NYC Department of Design & Construction
- NYC Economic Development Corporation

OPEN LOOP GEOTHERMAL SYSTEMS

CLIENT: AMNEAL PHARMACEUTICALS
CONTACT: SANJIV PATEL, SENIOR VICE PRESIDENT, OPERATIONS
SITE: 80 STATION ROAD, YAPHANK, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

PWGC provided feasibility analysis, design, permitting, modeling and construction oversight services for a new, large-scale open loop geothermal well system. The system is used for year-round facility cooling and process cooling of a large pharmaceutical manufacturing facility. Peak demand of the geothermal system is being designed to deliver 3,600 gpm of groundwater to the chillers. The system includes three (3) supply wells each rated for 1,200 gpm and a total of nine (9) return/diffusion wells. The wells are on average 175 feet deep each installed into the Upper Glacial Aquifer. The well field has been installed and is presently being tied into the building side of the system.

PWGC's ROLE

PWGC developed a 3D numerical groundwater flow model of the regional geology and hydrogeology of glacial outwash deposits along the south shore of Suffolk County. Each of the major hydrogeologic units, besides the shallow aquifer, including the Gardiner's Clay, Monmouth Greensand and Magothy aquifer were simulated and calibrated within the boundaries of the model. PWGC integrated a thermal component into the model to aid in securing regulatory approval as the site was located between two Suffolk County Water Authority well fields, specifically to demonstrate that the system would not result in a negative environmental impact on the drinking water supply wells. In addition, a heat transport modeling was used to locate the on-site geothermal wells to avoid thermal "short circuiting" between supply and return wells.

- PWGC's provided the following services:
- Prepared feasibility study and preliminary cost estimate.
- Designed, coordinated and oversaw vertical profile test boring and groundwater quality samples collection.
- Prepared Long Island Well Permit Application including 3D numerical sub-regional groundwater model to simulate groundwater flow patterns and heat transport.
- Prepared engineering design and construction documents.
- Provided full range of construction administration services from bid phase through project closeout.
- Provided part-time on-site construction observation services throughout the duration of the project.

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CLOSED LOOP GEOTHERMAL SYSTEM

CLIENT: JAG ARCHITECTS
CONTACT: JOHN GRILLO, PRESIDENT
SITE: 2685 MONTAUK HIGHWAY, BRIDGEHAMPTON, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

PWGC provided geothermal consulting, design, modeling, and construction oversight services for a new closed loop geothermal ground source heat pump system for the preK-12 grade Bridgehampton School. The system is used for year-round cooling and heating for the school's 35,000 square foot building expansion and retrofit of the 30,000 square foot existing building.

Peak demand of the geothermal system was designed to deliver 565 gpm of circulating fluid to the building heat pumps. The system includes ninety (90) boreholes and are on average 355 feet deep each. The well field has been installed underneath the athletic field located south of the building.

PWGC's ROLE

PWGC designed, and managed all aspects of, the geothermal well field (boreholes, circuit piping, main piping, valves, and geothermal vault). Designs included borehole location, size, depth, and material. Further, PWGC designed and supervised construction of a geothermal test borehole to conduct a thermal conductivity test to assist in the design of the geothermal system. PWGC developed a ground source heat pump model of the geothermal system based on the mechanical specifications provided by the mechanical engineer.

- PWGC's provided the following services:
- Designed, coordinated, and oversaw test borehole.
- Prepared engineering design and construction documents.
- Provided full range of construction administration services from bid phase through project closeout.
- Provided part-time on-site construction observation services throughout the duration of the project.
- Prepared the O&M manuals for the project and continues to provide guidance on system operation and periodic maintenance activities.

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OPEN LOOP GEOTHERMAL SYSTEM DESIGN

CLIENT: AKF ENGINEERS, LLP
SITE: BROOKLYN NAVY YARD, BROOKLYN, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

Building 92 is an existing 9,200-square-foot historic structure, and the oldest building, on the grounds of the Brooklyn Navy Yard. The building was renovated and expanded in 2011 with 16,000 additional square feet of space. Indoor heating and cooling is being served by an open loop geothermal system.

PWGC provided full-service geothermal due diligence, field testing, design, and construction administration and observation services to the design team. PWGC initially designed and coordinated installation of two test wells, a 48 hour pumping test, and groundwater quality testing to evaluate the suitability of the site aquifer for an open loop system. PWGC subsequently designed the supply and return well field, piping system, manifold, and associated controls. Two supply wells and two diffusion wells were installed to convey the required flow of 140-gallons-per-minute through the geothermal heat pumps for producing heated and chilled water to fan coil units located throughout the building.

The project received LEED Platinum certification from the U.S. Green Building Council.

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INNOVATIVE GEOTHERMAL SYSTEM SITE INVESTIGATION & DESIGN

CLIENT: MEP ENGINEERING, PC
CONTACT: JEFF URLAUB, PE, PRINCIPAL/PRESIDENT/CEO
SITE: FIRST ACADEMIC BUILDING (FAB) FOR CORNELL TECH
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

PWGC was selected by Cornell University to develop a unique geothermal system to serve the first building constructed for Cornell's Technology–Focused Campus ("Cornell NYTech") on Roosevelt Island, New York, NY. The Bloomberg Center will be a science education and research facility of approximately 150,000 sf with a projected peak (dominant) cooling load of approximately 300 tons. The goal for the building is LEED certification and Net Zero Energy usage.

Based on earlier site testing showing prolific groundwater flow in the bedrock geologic formation beneath the site, Cornell envisioned using an innovative closed loop borefield comprised of highly-efficient un-grouted ("groundwater filled") boreholes connected to modular reversible chillers in the building's mechanical plant. This was believed to be the first of its kind in this country. PWGC developed and coordinated a site investigation for Cornell to test the concept, which included installation and hydraulic and thermal testing of three boreholes, and thermal profiling and modeling using the resulting data. An "annulus pumping" mode was evaluated as part of the design that would moderate entering water temperatures to the chillers thus provide higher overall HVAC system efficiencies.

The concept was successfully vetted and Cornell elected to proceed with the innovative design. The PWGC team was selected under a subsequent RFP issued by Cornell to prepare final design and build the system. Construction of the building and an 80-loop geothermal borefield and annulus pumping system was completed and the system has been operating successfully. The annulus pumping option is believed to be the first use of this technique globally.

Given the building's strongly cooling dominant load profile, supplemental hybrid cooling capacity was provided by a conventional cooling tower, in addition to the annulus pumping system. It is notable that neither the annulus pumping system nor cooling tower have been needed to date, demonstrating the high efficiency of the groundwater-filled borehole design.

CLOSED LOOP GEOTHERMAL SYSTEM DESIGN

CLIENT: BARACK OBAMA PRESIDENTIAL LIBRARY
SITE: CHICAGO, IL
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

PWGC provided geothermal consulting services including environmental due diligence, schematic design, field testing coordination, bidding, design development and construction documents for the project, which is about to enter the construction phase. PWGC will perform construction administration, observation, operation and maintenance support, and project management throughout the construction phase of the project. Due to an active NDA, PWGC is unable to provide project-specific information. The system was designed and approved in conjunction with a diverse team of consultants including engineers, energy modelers, cost consultants, third party reviewers, city officials, construction managers and subcontractors.

Peak demand of the geothermal system is designed to deliver approximately 1,500 gpm of circulating fluid to the proposed buildings and provide heating, cooling, hot water production, dehumidification, and exterior snow melt systems along sidewalks. The system includes approximately (184) boreholes and will be an average of 500 feet deep each. The well field will be installed underneath a proposed subgrade parking structure, and underneath proposed landscape features such as amphitheaters, sidewalks, utilities, and other site features.

PWGC'S ROLE

PWGC designed, and managed all aspects of, the geothermal well field (boreholes, circuit piping, main piping, valves, and geothermal manifolds). Design thus far included borehole location, size, depth, and material. Further, PWGC designed and supervised construction of four geothermal test boreholes to confirm the geology of the area, as well as perform thermal testing to gather thermal capacity data of the geology for design optimization. PWGC developed a ground source heat pump model of the geothermal system, with the help of the team, to minimize the footprint of the geothermal system, to reduce costs while not sacrificing redundancy.

PWGC's provided the following services:

- Due diligence, feasibility, and schematic design reporting.
- Development of a field testing scope, preparation of field testing bid documents and subcontractor selection.
- Oversight of subcontractors performing test loop installation and testing.
- Prepared several options for the Client based on site-specific data.
- Performed load calculations to ensure the geothermal system is unaffected by the proposed parking structure to be located above a portion of the borefield.
- Attended virtual meetings with the Client and design team, participated in several peer-reviews of our proposed design, justifying it to the team.
- Prepared engineering design and construction documents.

PWGC will provide the following services:

- Provide full range of construction administration services from bid phase through project closeout, including meetings with the construction manager/general contractor, to ensure a seamless installation, particularly for those unfamiliar with geothermal technology and installations.
- Provide part-time on-site construction observation services throughout the duration of the project construction.
- Prepare the O&M manuals for the project and continues to provide guidance on system operation and periodic maintenance activities.

GLEN COVE HOSPITAL GEOTHERMAL SYSTEMS REPLACEMENT

CLIENT: NORTHWELL HEALTH
CONTACT: MICHAEL KRAUS, ENGINEERING MANAGER
SITE: GLEN COVE HOSPITAL
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

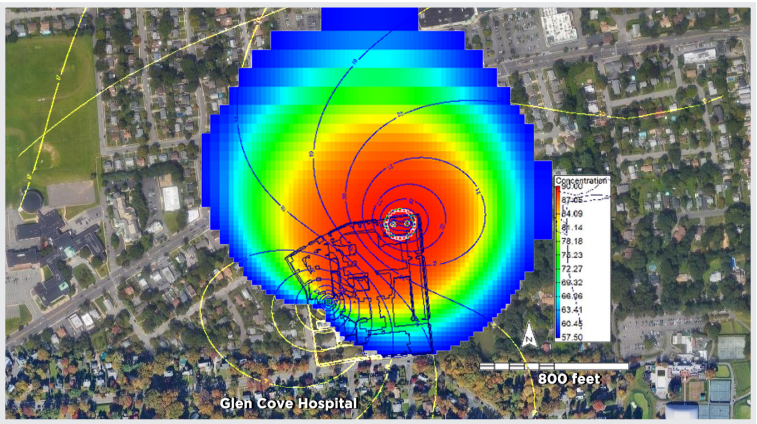
Analysis, design, permitting, modeling and construction oversight of two new open loop geothermal well systems. New systems replaced aging and failing existing open loop geothermal well systems. One system was 650 gpm and situated in the Lloyd Aquifer and the other was 180 gpm situated in the Magothy Aquifer.

PWGC's ROLE

- PWGC prepared feasibility study and preliminary cost estimate
- PWGC prepared engineering report including 3-D numerical sub-regional groundwater model that included fate and transport modeling for Freon R-22, Thermal plume, hydraulic effects to saltwater interface in the Lloyd Aquifer
- PWGC designed five (5) new wells and rehabilitated two (2) exisiting wells in Glen Cove
- Prepared Long Island Well Permit Applications
- Prepared engineering design and construction documents
- Provided full range of construction administration services from bid phase through project closeout
- Provided full time on-site construction observation services throughout duration of project (8 months) including commissioning services

Developed sub-regional 3-dimensional numerical groundwater flow model that involved the complex geology and hydrogeology of the Glen Cove area peninsula in Northern Nassau County. Each of the major hydrogeologic units including the North Shore Confining Unit and the North Shore Aquifer were extensively developed and calibrated. Model was developed to aid in approval of engineering report as one of the existing open loop geothermal wells systems being replaced was installed in the highly sensitive Lloyd Aquifer. Model was used to demonstrate that no appreciable or significant negative environmental effects or impacts would occur as a result of continued use of the Lloyd as a geothermal resource. Additionally in an unrelated matter the calibrated model was used for fate and transport modeling of Freon R-22 as the City of Glen Cove was detecting low concentrations of the contaminant in its nearby by Seaman Road well field.

As several of the proposed wells to be installed in the Lloyd Aquifer were over 500 ft deep the project required approval of the NYSDEC Division of Mineral Resources (DMR).



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ENGINEERING CONSULTING & GEOTHERMAL WELL DESIGN SERVICES

CLIENT: LONG ISLAND UNIVERSITY, C.W. POST CAMPUS
CONTACT: FRANK CASALE, PROJECT MANAGER/FACILITIES MANAGEMENT
SITE: WINNICK HOUSE, C.W. POST CAMPUS
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

For the renovation of the Winnick House, which accommodates the administrative offices for C.W. Post staff. The client proposed a geothermal cooling well system (GCWS) to provide air-conditioning during the summer season.

PWGC's ROLE

The client requested PWGC to perform a feasibility study, NYSDEC well permitting and to design, and manage construction of the proposed system. PWGC conducted a technical review of available published data regarding groundwater quality, site topography and both hydraulic and geologic constraints for the GCWS installation and beneficial economic operation,

Based on the review, PWGC determined the system, which was to consist of one groundwater supply and 2 diffusion (groundwater re-charge) wells to be feasible and commenced with the design. PWGC initially calibrated and ran a 3-dimensional groundwater model to locate supply and diffusion wells, which would serve to minimize thermal breakthrough in the Magothy Aquifer and ensure optimal efficiency of the GCWS within site constraints. Using the results of groundwater modeling data, and field surveys, PWGC proposed well locations that provided easy access during construction, minimal disruption to campus operations, and future maintenance/rehabilitation access.

OPEN LOOP GEOTHERMAL SYSTEM

CLIENT: NEW YORK INSTITUTE OF TECHNOLOGY
SITE: 700 NORTHERN BLVD., OLD WESTBURY, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

Analysis, design, permitting, modeling and construction oversight of a large scale open loop geothermal well system that will service multiple campus buildings including dormitories, office space and food service. Peak demand of geothermal system is being designed for 2,250 gpm of groundwater. System will include at least three (3) separate supply wells of 750 gpm each and a total of 6 diffusion wells. Entire system is to be located in the Magothy Aquifer.

PWGC's ROLE

PWGC developed sub-regional 3-D numerical groundwater flow model that involved the geology and hydrogeology of moraine deposits along the center and north shore of central Nassau County. Model had to take into consideration extensive nature of local groundwater fed streams that acted as drains causing significant flow pattern disruptions. Each of the major hydrogeologic units including the Upper Glacial, Magothy and Lloyd Aquifers as well as the Raritan Confining Unit were extensively developed and calibrated within the boundaries of the model. Nearby surface water and saltwater bodies such as Hempstead Harbor were included in the model as well. The model was developed to aid in approval of engineering report as nearby public water supply well fields and other existing open loop geothermal systems were in proximity to the proposed NYIT system. The model was used to demonstrate that no appreciable or significant negative environmental effects or impacts would occur as a result of withdrawing and recharging 2,250 gpm of groundwater under peak demand conditions. Additionally due to the large size of the geothermal system, a heat transport was modeled to investigate if thermal breakthrough or short circuiting would occur and to help aid in locating and spacing the supply and return wells.

PWGC provided the following services:

- PWGC prepared feasibility study and preliminary cost estimate
- PWGC prepared engineering report including 3-D numerical sub-regional groundwater model to estimate groundwater flow and heat transport
- Prepared Long Island Well Permit Applications
- Designed, coordinated and oversaw test well construction, soil and groundwater quality samples collection, performance of 72 hour pumping test and analysis of test data to aid in final system design
- Prepared engineering design and construction documents
- Provided full range of construction administration services from bid phase through project closeout
- Provided part-time on-site construction observation services throughout the duration of the project

VERTICAL CLOSED LOOP GEOTHERMAL SYSTEM DESIGN

CLIENT: GLUCKMAN MAYNER ARCHITECTS & NYC DEPARTMENT OF DESIGN AND CONSTRUCTION
CONTACT: JEREMY LOCKARD (NYCDDC), PROJECT MANAGER
SITE: STATEN ISLAND INSTITUTE OF ART & SCIENCES
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

The Staten Island Institute of Arts and Sciences (SIIAS).is part of the Snug Harbor Cultural Center (SHCC), which is a National Historic Landmark located on 83 acres on Staten Island's north shoreline. SHCC is home to a diverse set of arts and cultural institutions including the SIIAS.

A vertical closed loop system will supply all of the heating and cooling needs for an existing, Greek revival architecture building that is undergoing full interior renovation to be the new Staten Island Museum. The geothermal system will provide centralized air conditioning for the building for the first time in its history. Building A has an estimated peak cooling demand dominant load of 114 tons. The loop field will consist of 32 loops, each to a depth of 500 feet.

PWGC's ROLE

PWGC was responsible for field testing and design of the loop field, supply and return piping and headers, and the manifold vault which will be located outside the mechanical room within the center of the loop field. PWGC also specified the piping system pressure testing and purging/flushing procedures, and all associated sensors, P/T gauges and valves. PWGC developed a conceptual layout of the loop field to take advantage of a large field adjacent to the building. Coordination with NYC Parks Department was required to ensure protection of old specimen trees bordering the field.

In advance of the design, PWGC developed a request-for-bid package and obtained bids from drilling firms to install and conduct thermal testing of two test loops. The test loops established drilling conditions, geologic profile, and thermal conductivity data for input for the full scale design. PWGC provided full-time inspection of the test loop installations. The test loops will ultimately be incorporated into the full-scale closed loop field.

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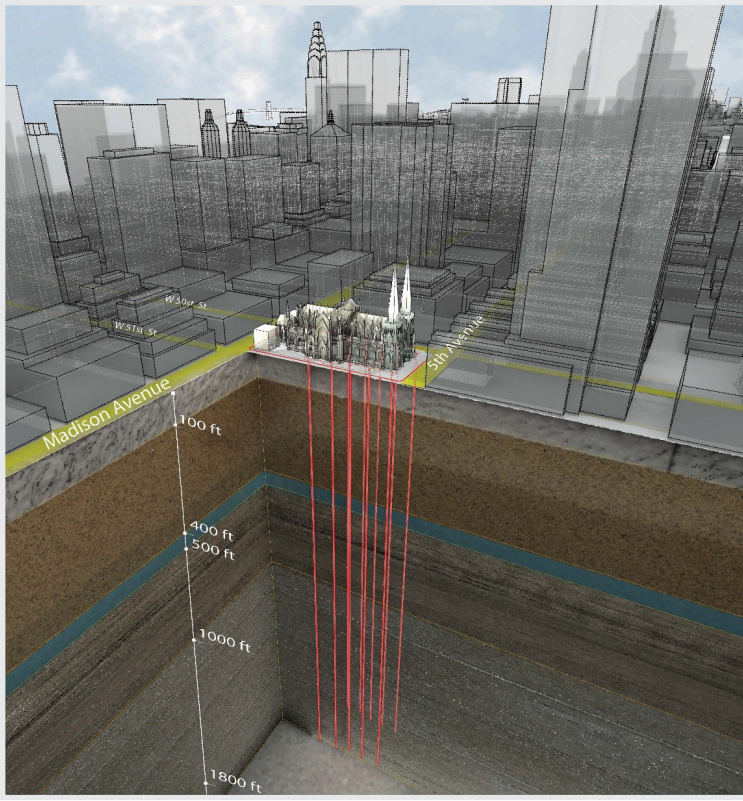
STANDING COLUMN WELL GEOTHERMAL SYSTEM

CLIENT: MBB ARCHITECTS
CONTACT: JEFFREY MUPRHY, FAIA, PARTNER
SITE: ST. PATRICK'S CATHEDRAL
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION



Starting in 2006, The Trustees of St. Patrick's Cathedral (Trustees) engaged an architect and consultants to evaluate upgrade of the cathedral's aging heating and cooling system. In 2009, P.W. Grosser Consulting, Inc. (PWGC) was engaged to assist in evaluating a geothermal system option. PWGC initially participated in feasibility analysis and screening of the geothermal option versus a new conventional system and an option to purchase heating and cooling produced at Rockefeller Center's plant across 5th Avenue. The Archdiocese selected a geothermal system due to many significant benefits over the other options, including eliminating use of steam heating and energy-intensive chillers, more favorable life-cycle costs, and more in line with the church's goal of increased environmental stewardship. In addition, there is a greater acceptance of this technology by the city's Landmarks Preservation Commission since all of its components are either buried or indoors (in a mechanical plant).

PWGC designed the "well side" of the HVAC system, including a 10-well standing column well system, associated piping to the plant, and the manifold that ties the wells to the building mechanical equipment via a series of plate-frame heat exchangers. The wells were drilled through dense Manhattan schist bedrock under observation by PWGC geologists and engineers, and ranged in depth from 800 feet to 2,200 feet. PWGC developed and implemented a field testing program during the drilling that included multi-well pump testing, groundwater sampling, and borehole geophysical logging. The data were used to evaluate the rock hydraulic and groundwater conditions to confirm the selection of well components and well sequence of operation. PWGC also provided construction support during installation and testing of the horizontal supply and return piping, and interior equipment including the manifold, filters, and controls. PWGC has participated in system startup and monitoring since the plant became operational in February 2017.

The geothermal system was designed to supply the entire base load of the cathedral and adjoining buildings, with supplemental conventional cooling tower capacity available during peak cooling periods. To date the wells alone have been sufficient without the need to engage the cooling tower. The project was completed on time and within budget and went beyond the Owner's objective of bringing the facility's heating and cooling system up to modern standards while preserving of the historic architectural fabric of this architectural icon. The system is projected to result in 25 percent lower annual energy costs and 94,000 Kg lower annual CO_2 emissions compared to the traditional HVAC options.

MASTER PLAN

CLIENT: THE ROSS SCHOOL
SITE: EAST HAMPTON, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

The Ross School, located in a wooded, groundwater recharge protection area of eastern Suffolk County and consists of five (5) buildings and several rented suites, intended to expand to adjacent property owned by Ross Institute, and which included 130 acres of undeveloped woodlands. The Ross School assembled a team to develop a master plan and conceptualize a campus-like layout, which would incorporate sustainable design into its vision as an environmentally conscious entity.

PWGC's ROLE

PWGC directed the project and served as key strategic/technical advisor to integrate the planned campus-like setting into the Town of East Hampton's (Town) infrastructure. PWGC was responsible for investigating, reviewing and recommending sustainable solutions aimed at minimizing the impact to the environmentally sensitive area of the proposed site that addressed the client's civil and environmental engineering objectives. Specifically, PWGC was responsible for the following:

- Managed the water resource impacts evaluation by researching alternatives to minimize the project's potential impacts on the groundwater. This included various methods of wastewater treatment - such as a solar aquatics system - water use and water re-use for turf management, and storm water control practices.
- Prepared the project's master plan in collaboration with team consultants, regulatory agencies, utility companies, and regional planners. Addressed potential short and long-term impacts on the environment, and the Town, including cultural, socio-economic and quality-of-life issues, which focused on water resources and utility needs.
- Served as liaison to regulatory agencies. Supervised R&D sections of report pertaining to cost and planning of water resources and wastewater; Irrigation and drainage collection system; turf and integrated pest management (IPM); geology/ hydrogeology analyses; geothermal energy systems, and hazardous materials strategies

To support the sustainable planning for the projects execution, PWGC also prepared estimates for water use and ecological wastewater generation based on anticipated populations and facility use of the complete campus and on building by building basis; cost estimates for the wastewater treatment plant and campus wide wastewater collection as well as designs for the utility layout, traffic controls, roadways and aesthetic water features.

CLOSED LOOP GEOTHERMAL SYSTEM RETROFIT

CLIENT: VALLEY STREAM SCHOOL DISTRICT
CONTACT: CHARLIE BROCHER, SUPERVISOR, SCHOOL FACILITIES AND OPERATION
SITE: 75 HORTON AVENUE, VALLEY STREAM, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

PWGC received the call for this project in 2019 and provided services including a thorough inspection of the existing heat pump system at the site, preparation of a professional opinion report including six options for the client with cost estimates, and attended meetings on behalf of the client, including Board meetings, meetings with regulatory agencies, and meetings with the school's attorney.

Prior to the project, the district was part of a pilot-study program in 2015, led by the local domestic water supplier, New York American Water (NYAW) in which heat pump equipment was provided to the school building. The heat pumps were set up to transfer heat between the building and NYAW's potable water distribution system. Ultimately, the pilot program was unsuccessful, as utilizing potable water for heat transfer and pumping it back into the public water supply is considered a cross-connection by the local Health Department. As a result, the district was discharging potable water into the sewer, after it exchanged heat with the building. After several years of operating in this wasteful fashion, NYAW was pressuring the district to pay for the potable water supply, as well as pay the sewer fees for discharging the water. Operating this way would not only be wasteful but put the district in extreme financial distress (estimated at approximately $300,000 per year in water and sewer fees). To avoid this, the district decided to hire PWGC to execute one of the six options provided early in 2020 – converting the system to a closed loop geothermal system.

PWGC provided services to the client including a field-testing program, field testing bid documents, and assisted the district in selecting the field-testing subcontractor. Further, PWGC oversaw the testing program, developed al schematic design, submitted the project to the New York State Education Department (NYSED), submitted applications required by the State Environmental Quality Review Act (SEQRA), attending meetings, developed construction and bid documents for the geothermal, mechanical, electrical and plumbing components of the proposed project, coordinated with NYAW and facilitated the transition of ownership between NYAW and the district. PWGC also provided construction administration, oversight and field reporting, project management, and commissioning services for this project, along with facilitating the installation of a natural gas line.

The system is used for year-round cooling and heating for the school's 100,000 square foot building and includes redundancyfor the school's future expansions, renovations, and summer-school programs. The system includes fifty (50) boreholes and are on average 500 feet deep each. The well field has been installed underneath the lawn and ballfield area in the southeast corner of the property. A natural gas fired back-up boiler was required by NYSED for heating redundancy, though it is not expected to be utilized as the geothermal system was designed to eliminate fossil-fuel consumption for the school. To cut down on costs, the district requested applicable existing equipment be re-used for the project, so PWGC was able to re-utilize portions of piping, controls, and several circulator pumps.

CLOSED LOOP GEOTHERMAL HEAT PUMP SYSTEM UPGRADES

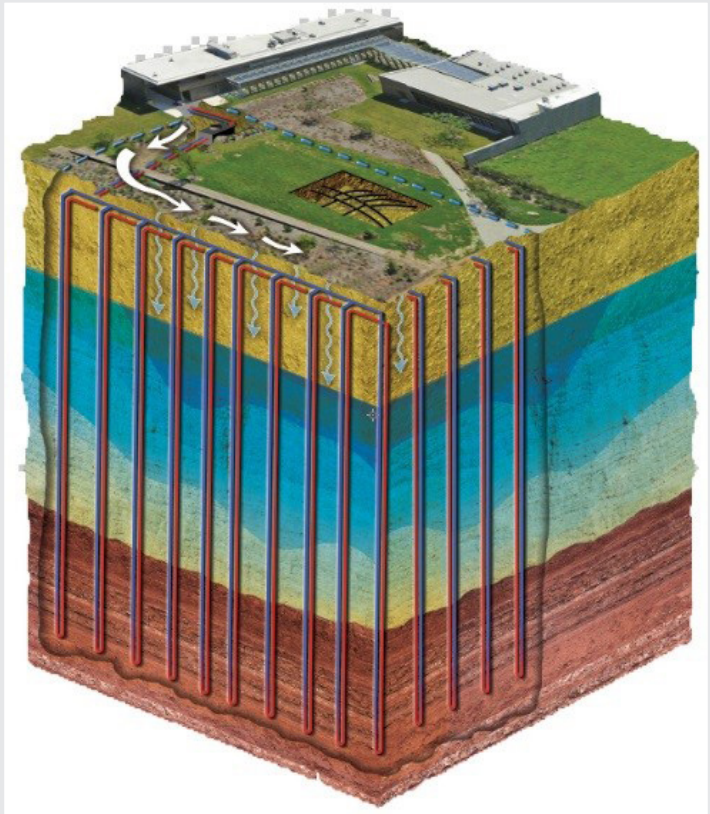
CLIENT: NYC DEPARTMENT OF DESIGN & CONSTRUCTION
CONTACT: JEREMY LOCKARD, PROJECT MANAGER
SITE: WEEKSVILLE HERITAGE CENTER, BROOKLYN, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

The Weeksville New Education Building site in Bedford Stuyvesant, Brooklyn, New York, is home to a cluster of original, U.S. Civil War-era domestic structures - the historic Hunterfly Road Houses dating from 1840–1880s - that were part of the African American community of Weeksville. The new building houses a new venue for Weeksville's educational events.

For the New York City Department of Design and Construction, PWGC designed a closed loop geothermal system for the building, constructed in 2013, that is supplying the full heating and cooling needs of the building. The closed loop borefield consists of 48 loops each drilled to a depth of 470 feet. Given the building's cooling dominant load profile (peak cooling load of 90 tons), PWGC designed in the ability to tie in a dry cooler in the future to supplement the geothermal system, if needed, during peak cooling periods.

PWGC was responsible for implementing a test closed loop and thermal conductivity testing, design of the borefield, supply and return piping and headers, and the buried manifold vault located outside adjacent to the mechanical room. PWGC provided construction administration and full-time inspection services during construction, including witnessing start up testing procedures and performance tests. The project has earned LEED Gold certification from the U.S. Green Building Council and a Platinum Engineering Excellence Award to PWGC by the American Council of Engineering Companies.



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GEOTHERMAL HEAT PUMP MANUAL

CLIENT: NYC DEPARTMENT OF DESIGN AND CONSTRUCTION
CONTACT: JEREMY LOCKARD, PROJECT MANAGER
SITE: NEW YORK, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

The New York City Department of Design and Construction (NYCDDC) has been the pioneer in evaluating and developing geothermal projects in the five (5) boroughs for nearly 15 years, and PWGC staff have assisted them over this entire time span. Besides designing new systems for NYCDDC and troubleshooting existing systems designed by others, NYCDDC selected PWGC in 2011 to re-write its Geothermal Heat Pump Manual, orginally published in 2002. The Manual is a “how to” document that quickly became, and remains today, a well-referenced standard for the industry, both locally and nationally. The updated manual was published in 2013 and is available online at:

http://www1.nyc.gov/assets/ddc/downloads/Sustainable/GeothermalHeatPumpManual.pdf

GEOLOGIC MAPPING FOR GEOTHERMAL FEASIBILITY

CLIENT: GOOGLE(X)
SITE: VARIOUS SITES
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

"X", the research arm of Google, identified geothermal systems as a potentially transfomative technology worth vetting for mass adoption. One of X's main objective was to evaluate methods to install ground heat exchangers (GHXs) much quicker than the industry standard. Reduced on-site drilling time and loop installation should naturally translate to lower costs and greater uptake of technology. X engaged PWGC to research surficial geologic conditions for 10 states in the U.S., including all New England, New York, New Jersey, Delaware, Minnesota, and Iowa. PWGC compiled state and U.S. Geological Survey surficial geologic maps in GIS, culled the data relative to the Client's objectives, and developed GIS layers of the various mapped geologic formations matched to the relative ease of installation of GHXs. PWGC also compiled regulatory agency website links and publicly available, online geologic and well data records.

WEB-BASED GEOTHERMAL FEASIBILITY SCREENING TOOL

CLIENT: NYC MAYOR'S OFFICE OF SUSTAINABILITY & NYC DEPARTMENT OF DESIGN AND CONSTRUCTION
CONTACT: JEREMY LOCKARD, PROJECT MANAGER
SITE: NEW YORK, NY
PROJECT MANAGER: PAUL K. BOYCE, PE, PG, PRESIDENT/CEO

PROJECT DESCRIPTION

PWGC served on a consultant team working for the NYC Mayor's Office of Sustainability (MOS) and NYCDDC to develop a publicly available, web-based geothermal feasibility screening tool for the five (5) boroughs. The tool was required by Local Law 6 of 2016 as part of the city's "80 by 50" initiative to improve energy efficient of its building stock and reduce green house gas emissions. PWGC's role was to develop geologic maps in GIS format to integrate into the tool and to map areas in the city where geothermal systems are geologically and technically suitable. The tool can be accessed at:

http://www1.nyc.gov/assets/ddc/geothermal/index.html