SECTION 170100 – GEOEXCHANGE TESTING SPECIFICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the furnishing of all equipment, materials and labor reasonably incidental for the complete installation of two (2) closed-loop ground heat exchanger test bores with one (1) bore being tested.

B. Work shall be conducted in accordance with the requirements of this Section.

C. The Contractor is responsible for securing all required drilling permits in the name of the Owner. The Contractor shall pay for all permitting costs.

D. As part of the bid, the Contractor is required to break out unitary pricing ($/linear ft.) for casing the bore. Should it be determined necessary to case the bore during the installation, this unitary price will be used.

E. Scope: Two (2) vertical bores shall be installed according to these specifications. The completed bores shall be located so that it is incorporated into the final ground-loop heat exchanger design. A completed vertical test bore shall consist of the SDR-11 ASTM 4710 (200 psig rated) vertical bore with an approved polyethylene u-bend assemble installed to the completed bore depth with an approved grouting material installed in the bore annulus. Vertical bore can be drilled by a mud-rotary drilling rig or by a compressed-air drilling rig whichever is most feasible based on geological conditions. Drilling contractor shall provide a detailed test bore report for each bore. The report shall include the following information:

1. Each formation type encountered (drill log)
2. Each formation depth (in feet)
3. Depth of any significant cracks, fissures or caverns encountered
4. All water bearing ones and if encountered:
   a. Zone depths
   b. Estimated flow rate
5. Type of drilling equipment used (i.e. mud-rotary, air-rotary, air-hammer, etc.), and rig model number
6. Bag quantity of drill mud used where applicable
7. Total time to drill the test bore excluding shutdowns to obtain water or mechanical breakdowns.
8. A completed, signed report shall be supplied immediately at the conclusion of the drilling process.
9. The Work also includes flushing and purging of the test bore piping system. The closed-loop ground heat exchanger consists basically of polyethylene heat fusion joined piping formed into vertical loops, for future connection to the extended range water-source heat pump units to provide an ARI 330 ground source closed-loop heat pump system.
10. Contractor to provide 40’-0” length of 6” steel casing as part of the base bid. Contractor to provide a unit price per linear foot for additional steel casing over the 40’-0” length.

1.2 REFERENCES

A. American Society for Testing and Materials

1. ASTM D1693 -Standard Test Method for Environmental Stress -Cracking of Ethylene Plastics.
2. ASTM D2321 -Standard Practice for Underground Installation of Thermoplastic for Sewers and Other Gravity-Flow Applications.
3. ASTM D2447- Standard Specification for Polyethylene (PE) Plastic Pipe Schedules 40 and 80 Based on Controlled Outside Diameter.
4. ASTM D2487 -Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
5. ASTM D2513-OQ -Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
6. ASTM D2683 -Standard Specification for Socket -Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
7. ASTM D2837 -Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
8. ASTM D3035-95 -Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
9. ASTM D3261 -Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
10. ASTM D3350 -Standard Specification for Polyethylene Plastic Pipe and Fittings Material.

1.3 SUBMITTALS

A. Shop Drawings: Detailed 1/8-inch scale layout drawings of the closed-loop ground heat exchanger test bores showing all other existing underground utilities and relationship to new proposed bore field for coordination purposes.

B. Product Data: Submit manufacturer's product data and installation instructions for closed-loop ground heat exchanger piping, materials and products.

C. Manufacturer's Certificate: Pipe manufacturer shall supply a notarized document confirming compliance with the specifications of this Section.

D. Warranty: D/L must submit 2-year parts and labor warranty certificate covering all work performed.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: 1/8-inch scale record drawings and dimensions showing exact location of the test bores.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with Connecticut EPA standards.

1.6 QUALIFICATIONS

A. Contractor: Firms regularly engaged in installation of closed-loop ground heat exchanger, and/or projects of similar scope of the type, material and size required; whose installations have been in satisfactory use in similar service for not less than five

years. The contractor shall supply, with the bid, information on past jobs of similar scope. The following information must be supplied:

1. Name of project/customer.
2. Location of project.
3. Customer contact name (reference) with phone numbers.
4. Project designer/engineer.
5. Date of installation.
6. Number of wells.
7. Depth of wells.
8. Grout used.

B. Manufacturer: Company specializing in manufacturing of closed-loop ground heat exchanger products and tools of the types, material and size required; whose products have been in satisfactory use in similar service for not less than three years.

C. Installer: The Drilling Contractor shall be licensed in the State of Connecticut. Installers shall have at least two years of successful installation experience on projects with closed-loop ground heat exchanger work and/or projects of similar scope to that required for this project. Drilling Contractor must have experience at mixing and pumping pre-engineered cementitious grout materials with simultaneous placement of the pipe assembly and tremie tube from the bottom of the borehole to the top.

D. Fabricator must have completed a certification training program offered by the International Ground Source Heat Pump Association (IGSHPA) or approved manufacturers' certification program and shall have at least two years of successful installation experience. The only acceptable method of joining buried plastic pipe system is by heat fusion process. Each ground heat exchanger fabricator must have performed a fusion procedure under direct supervision of an IGSHPA Certified Heat Fusion Technician, an IGSHPA approved manufacturer's certification program or a DOT certified heat fusion technician. Each certified technician must attend a retraining school annually.

1.7 PRE-INSTALLATION CONFERENCE

A. Convene a minimum of one week prior to commencing Work of this Section.

B. Facility director shall be notified 72 hours prior to commencing with Work of this Section.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Pipe, fittings and cementitious grouting material shall be stored on site in designated area that will not interfere with the operations of the Owner.

C. All pipe fittings are to be sealed to prevent debris, rodents and other foreign material from entering the piping system.

D. Palletized cementitious grouting materials are to be protected from the weather with a protective cover.

E. Topsoil shall not be muddy or frozen.

1.9 FIELD MEASUREMENTS

A. It is the contractor's responsibility to call the Connecticut One Call System to determine if any existing underground utilities are located in the proposed test bore site. The Contractor will coordinate with the Owner or Owner's representative to locate any "Customer/Owner" underground utilities not covered by the Connecticut One Call System. If any "marked" or located underground utilities are damaged during the test bore operation, it will be the Contractor's responsibility to properly repair and return the utility to service.

B. Ensure the proper site protection is in place for the moving, setting up, operating and removal of the drill rig and other support vehicles or equipment, including protection of curbs and sidewalks, protection of existing trees, shrubs and lawn. Contractor will inform the Owner of any obstacles to the drilling operation before actions are taken to remove obstacles.

1.10 WARRANTY

A. Furnish minimum twenty-five-year warranty for piping.

PART 2 - PRODUCTS

2.1 CLOSED-LOOP GROUND HEAT EXCHANGER PIPING AND MATERIALS

A. Manufacturers: Polyethylene pipe shall be manufactured by NuMex Plastics or approved equal.

B. The only acceptable pipe and fittings material for the underground portion of the ground heat exchanger is high-density polyethylene. Specifications for the polyethylene heat exchanger are as follows:

1. General: All pipe and heat-fused material shall be manufactured from virgin polyethylene extrusion compound material in accordance with ASTM D-2513, Sections 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness and respective tolerances as specified in ASTM D3035 or D2447.

2. Material:
   a. The material shall maintain a 1600 psi Hydrostatic Design Basis at 73.4 degrees F per ASTM D2837, and shall be listed in PPI TR4 as a PE4710 piping formulation. The material shall be a high-density extrusion compound having a minimum cell classification of PE445574C or higher as specified in ASTM D-3350 except this material shall exhibit zero failure (F0) when tested for a minimum of 192 hours under ASTM D-1693, condition C, as required in ASTM D3350.
   b. Fittings shall meet the requirements of ASTM D2683 (for socket fusion fittings) or ASTM D3261 (for butt/saddle fusion fittings).

3. Dimensions:
   a. Pipe with a diameter through 1-1/4 inch (nominal) shall only be manufactured in accordance with ASTM D3035 with a dimension ratio (DR) of **11** and rated for **200 psi.**

4. Markings: Sufficient information shall be permanently marked on the length of the pipe. The appropriate ASTM pipe standard defines this information. All fittings shall also be similarly marked. Marked information shall include:
   a. Manufacturer's name.
   b. Nominal size.
   c. Pressure rating.
   d. Relevant ASTM standards.
   e. Cell classification number.
   f. Date of manufacture.

5. All piping used for the u-bend heat exchanger (pipe located in the borehole) will have factory hot-stamped lengths impressed on the side of the piping indicating the length of the heat exchanger to that point. The length shall read zero on the u-bend end and the actual heat exchanger total length on the other end.

2.2 PIPE JOINING METHODS

A. The only acceptable method for joining the buried pipe system is by the heat fusion process. Joining shall be of the socket, butt, saddle fusion, or electro fusion methods in accordance with the pipe manufacturer's procedures.

B. All fusion technicians shall be IGSHPA certified and properly trained and shall have executed quality fusion joints.

2.3 U-BEND/PIPE ASSEMBLY

A. The u-bend fitting shall be injection molded from PE4710 resin having a cell classification of PE445574C with a UV stabilizer of C. U-bends constructed by fusing two 90-degree bends together shall not be allowed. The u-bends shall be factory butt fused to continuous lengths of SDR 11 pipe, which has been extruded from resin identical to the u-bend. The u-bend/pipe assembly shall have pipe lengths long enough to reach to final grade from the bottom of the bore so that no field fusion welds are required below the header pit elevation. U-bend assemblies shall be factory pressure tested to 200 psi for a minimum of 5 minutes. On completion of testing, the pipe ends shall be immediately plugged to prevent foreign objects from entering the pipe.

2.4 THERMALLY ENHANCED CEMENTITIOUS GROUT

A. Grout Submittals: The successful bidder must provide submittals for approval by the Owner/Engineer on the grout and grout equipment 15 days prior to beginning work.

B. Grout Type: A Thermally enhanced cementitious grout shall be used to fill the annular space between the polyethylene pipe and the earth in all vertical well bores. The function of the grout is to facilitate the heat transfer between the u-loop and the surrounding earth formation while effectively sealing the borehole to prevent leakage of surface contaminants into the aquifers and/or cross-contamination between aquifers. The grout shall have a minimum thermal conductivity of 1.0 BTU/hr-FT-°F. No other backfill material shall be accepted. The grout shall be a cementitious-based grout, principally composed of two parts of finely graded silica quartz sand and one-part Portland cement (Type I or Type II), and may contain a stabilizer admixture to enhance pumping properties and to control working time. The grout shall be pre-blended dry at the factory and delivered to the jobsite in sealed bags. No additives except water shall

be added in the field. Thermally enhanced bentonite grout approved by CTDEP with a thermal conductivity greater than or equal to grout specified may be substituted.

C. Grout Mixing: Use a continuous paddle-mixer to mix the grout; batch mixing of grout shall not be allowed. The maximum water content of the grout shall not exceed 17% by dry weight of the grout mix. The grout shall be mixed with a Continuous Grout Mixer having an on-board roto-meter to precisely control the amount of water added. The grout shall contain a suitable admixture to achieve a slump of 6 to 11 inches at 17% water content, and shall exhibit an ASTM unconfined 28-day compressive strength greater than 3,000 psi. The mixed grout shall have a minimum specific gravity of 2.18 or density of 18.1 lbs/gallon.

D. Grout Placement: The boreholes shall be filled with grout throughout the entire depth of the borehole by pumping the grout through a tremie pipe extending from the grout pump at the surface to the bottom of the borehole using a coil-tubing unit. Although the tremie pipe will be withdrawn from the borehole as the grout is being pumped, the tremie pipe discharge opening must always be kept at a level below the top of the rising grout. A pressure gauge must be installed on the tremie line to indicate the location of the tremie pipe discharge.

1. In the event that a geological formation is encountered that prevents the grouting material from forming a solid seal, either a 3/8 inch (9.5 mm) or ¾ inch (19 mm) granular cementitious material may be used through that specific formation zone. Upon completion of that specific zone, the grout slurry shall continue to be used until reaching the surface of the vertical bore.
2. Grout type/manufacturer and percent solids shall be reported immediately to the engineer following bore completion.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which ground heat exchanger test bore system is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to owner/engineer’s recommendations.

B. The Contractor shall provide temporary water tanks and temporary electrical power as may be required for completion of work.

C. A water supply to fill temporary storage tanks will not be made available by the Owner.

3.2 INSTALLATION

A. Loop Insertion and Grouting

1. Drill borehole in accordance with local, State or Federal requirements. Follow all requirements for borehole drilling as prescribed by the State of Connecticut. The contractor will be responsible for receiving permission in writing from the State of Connecticut prior to proceeding and shall be responsible for maintaining any drilling logs that may be required.

a. The Contractor shall provide a written description (drill log) of the subsurface geology encountered during the drilling operation by a visual inspection of the drill cuttings. Information provided shall include: description of drill rig type and drill bit, drilling rates in feet per minute and types of formations. The Contractor shall provide this information for each change in geology for the entire depth of the bore hole and record the changes on the test bore report worksheet.

b. The Contractor shall advise the Owner/Engineer immediately in writing of the presence and depths of water, cavernous formations or any adverse drilling condition requiring casing of the bore hole. The contractor shall stop drilling operations until a response is received.

2. The borehole shall be clean and of a maximum diameter listed on the test bore report worksheet to facilitate the installation of the u-bend assembly and a tremie pipe. Care shall be taken so as not to stretch, crush, cut, or kink the pipe during installation.

3. Immediately prior to being placed in the borehole, the u-bend assembly shall be flow tested to ensure that there are no kinks, bends or pinches. The test shall consist of forcing clean water into one end of the assembly, and visually inspecting the discharge. If damage or an obstruction exists, that loop shall not be used.

4. If the driller has drilled deeper than indicated on the test bore report worksheet, special precautions shall be taken so that the sealed pipe ends do not "drop" into the open borehole below graded surface. If a buoyant condition exists, the u-bend shall be staked and tied at the surface to prevent the assembly from "floating" out of the bore prior to the "setting" of the cementitious-based grout.

5. Prior to grouting, the u-bend assembly shall be pressurized with water to achieve a minimum internal pressure of 50 psi, and the ends shall be temporarily plugged to maintain this pressure. To prevent the collapse of the pipe resulting from the external force created by the grout’s hydrostatic pressure, the pressure in the u-bend assembly shall be maintained until the grout has set.

6. Since some settling may occur after initial placement of the grout material, the installer shall monitor each test borehole and continue adding grout as required to bring the grout level up to the trench grade.

7. Borehole locations shall be individually surveyed after drilling is complete. The survey shall locate the test boreholes accurately from one or more known local survey benchmarks. The contractor shall furnish the Engineer/Owner a drawing indicating the test borehole locations

8. The contractor shall provide temporary security measures to protect the test bore and thermal conductivity testing equipment from vandalism until testing is complete. The Owner takes no responsibility for damage to or theft of Contractor’s equipment while said equipment is on site.

9. Following completion of thermal conductivity testing, the Contractor shall flush and seal the heat exchanger piping. The loop shall be no higher than 1-foot above

grade.

10. At the conclusion of drilling operations, the Contactor shall remove all drill cutting and trash from the site.

11. The Contractor shall provide temporary metallic enclosure left at or above grade for protecting the heat exchanger piping. A dimensioned “as-drilled” location plan has to be included in the final report.

3.3 ELAPSED TIME BEFORE TESTING

A. AIR ROTARY DRILLING: A minimum delay of five days between loop grouting and testing is required.

B. MUD ROTARY DRILLING: A minimum delay of three days between loop grouting and testing is required.

3.4 TESTING AND DOCUMENTATION

A. Testing is required on only one (1) borehole.

B. The Contractor shall insulate the supply and return piping between the bore hole piping and the thermal conductivity test and the exposed heat exchanger pipes above grade to ensure proper results.

C. Initial Ground Temperature shall be obtained by measuring and recording the loop temperature as the water returns from the test loop before start-up of the conductivity test.

D. Bore Thermal Conductivity: The Contractor shall utilize the in-situ testing equipment and methodology of an independent testing agency (in strict compliance with the recommendations of IGSHPA) to conduct a thermal conductivity of the completed geoexchange test bore. The thermal conductivity of the grout shall be established using a constant hot water source, which will simulate a load by adding a controlled amount of heat to the bore piping water. The heat flux rate shall be 15 to 25 Watts/foot of bore hole depth as that is the expected peak load on the heat exchanger U-Bend. In order to avoid potential power quality problems or power interruptions, the use of a portable generator is required (10 KW minimum). The contractor shall trend the heat transfer of the test bore fluid over a period of 48 hours at 5-minute intervals and provide graphs showing temperature versus time and temperature versus natural log of time to provide the actual thermal conductivity value and thermal diffusivity values. The process used shall be approved by the engineer prior to commencement of testing.

1. Equipment required for the test are the following:
   a. Ground heat exchanger in place (grouted)
   b. Constant hot water source
   c. Data acquisition system to measure and record
      1) Temperature in & temperature out
      2) Flow rate
      3) Volts and Amps or Watts

2. The test procedure to do the in-situ tests is outlined below.
   a. Locate in-situ trailer near well bore to minimize above ground pipe

exposure.

b. Flush loop to remove all debris, cap and set overnight, if possible, to obtain the most accurate ground temperature.
c. Connect ground loop to trailer.
d. Insulate loop leads to trailer to reduce temperature bias.
e. Finish filling loop and in-situ system with water.
f. Start data acquisition system, name the data file, adjust data recording rate to desired value, show the desired variables on screen in graph and digital form, begin recording data from the initial circulation.
g. Turn on pump and circulate the water for 15 to 30 minutes to obtain an average ground temperature. Circulate water at a high rate to flush the system, to eliminate air in the system. Adjust valve to maintain 10 to 15 psi pressure on the system. Minimize break-out if there is some air left in the lines by having a higher system pressure.
h. Adjust the flow rate at the test rate depending on the loop size. Make certain that the flow is turbulent, i.e. 6.0 gpm for 1-1/4" pipe will provide high Reynolds Number and stable flow.
i. Turn on the heaters to the desired wattage value.
j. Monitor screen for any anomalies in the data and periodically check for leaks in the pipe connections. Bleed air from the system as necessary and recharge from the water reservoir if necessary. Minimize any addition of water to the system after the test has begun.
k. When the temperature versus time curve begins to flatten out after a period of eighteen to twenty hours shut the heaters off and allow the temperature to decay for a period of time. If a qualitative heat dissipation rate is desired, then run the decay period until the loop temperature approaches the original ground temperature.
l. Shut the pump off and then log off the data acquisition system, making sure the file is closed and the data is saved. Transfer the data from the hard drive to a floppy diskette and provide a copy to engineer.
m. Remove insulation from the lines and disconnect the loop lines from the trailer and cap.

E. Grout Permeability: The grout mixture shall exhibit a nominal bulk grout permeability of 10^{-8} cm/second by using the "Falling-Head Method" (defined in the United States Army Corp of Engineers' Civil Engineering Manual No. EM 1110-2-1906, "Laboratory Soils Testing") as recommended by the U.S. Environmental Protection Agency. The average grout/pipe system nominal permeability shall be determined by using an experimental set-up as outlined in ASTM D 5084-90, and shall have a maximum nominal permeability rate of $1x\ 10^{-5}$ cm/sec.

F. The Contractor shall document in writing on the test bore report worksheet and final report, formation thermal conductivity and the formation thermal diffusivity.

G. Final Report shall be organized in a single document including the test bore report worksheets and three copies shall be submitted to the Project Engineer.

3.5 FIELD QUALITY CONTROL

A. Before backfilling the test bores, they shall be flushed and purged of air and flow tested to ensure all portions of the closed-loop ground heat exchanger test bores are properly flowing. A portable temporary purging unit shall be utilized and shall consist of the following:

1. Purge pump -high volume and high head.
2. Open reservoir.
3. Filter assembly.
4. Connecting piping.
5. Connecting hoses.

B. Using the purging unit described above, flush and purge each test bore free of air, dirt and debris. A minimum velocity of 2 feet second in each piping section must be maintained for a minimum of fifteen minutes to remove all air. A change of more than 1 inch in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system. After the flushing and purging operation with the supply and return lines, the pipe shall be capped and sealed at a point two feet below grade with an identifying marker at least one-foot above grade indicating the depth of the pipes.

3.6 FINISH GRADE PREPARATION

A. Soil spoils from the test bores not otherwise needed for backfilling or similar per specifications should be rough graded on site to return the site back to its approximate grade. Proposer to provide finished conditions that avoid unsightly or unsafe mounded soil conditions (mounds of soil, even if stabilized, may be an unsafe attractive nuisance to nearby playing school children). No soil import or export shall be permitted.

END OF SECTION