345 kV Underground Service Transmission Laterals Between Expanded Clay Substation and Micron Fabrication Areas

Exhibit E-3

Underground Construction

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EXHIBIT E-3: UNDERGROUND CONSTRUCTION

E-3.1 TYPE OF CABLE SYSTEM

Two basic technologies currently are available for 345kV underground transmission cable systems: high pressure pipe-type ("HPPT") systems and the high voltage extruded-dielectric ("HVED") technology proposed for this Project. The two cable technologies are described in the following paragraphs.

HPPT cable systems generally consist of three stranded copper or aluminum conductors that are insulated with paper or laminated paper polypropylene tapes and installed in a sealed and anti-corrosion coated steel pipe, with cathodic protection at one or both substation ends. The steel pipe is filled with dielectric fluid that is typically maintained at a pressure of approximately 200 pounds per square inch ("psi"). The pressurized dielectric fluid is a critical part of the electrical insulation system for HPPT systems. A fluid pressurizing plant is required at one or both ends of a HPPT cable system to maintain pressure on the cables and to accept fluid expansion and contraction with temperature changes. The plant contains a reservoir tank sized appropriately for the overall fluid expansion of the cable system, along with pressurizing pumps, relief valves, alarms and controls. The pressurizing plant is typically housed in a prefabricated equipment enclosure at a substation. The distance between manholes is typically 2,000 to 3,000 feet. HPPT cable systems have a proven service record dating back to the 1960's; however, there are concerns regarding the potential impact on the environment from fluid releases, increased maintenance cost as circuits age, and the lack of skilled labor to perform repairs. There is also only one remaining manufacturer of HPPT cables worldwide.

HVED cable systems incorporate three copper or aluminum conductors, each insulated with an extruded plastic material such as cross-linked polyethylene (also referred to as XLPE). Unlike HPPT systems, HVED systems do not require dielectric fluid for insulation. Individual single-phase cables are typically installed in polyvinyl chloride ("PVC") or high-density polyethylene ducts within concrete-encased duct banks. HVED cables generally are larger in diameter and heavier than the cables in an HPPT system, and the distance between manholes is typically 1,500 to 1,800 feet. HVED is a newer technology than HPPT at the 345 kV voltage. Operating experience to date has generally been positive, with significant installations in Europe and Asia, and with an increasing number of significant installations in North America. There are now dozens of HVED manufacturers worldwide.

Installation costs for HVED systems can be higher than for HPPT systems due to the need for additional and larger manholes. Additionally, a concrete-encased duct bank can be more difficult to fit between existing utilities than a steel pipe, resulting in the need to bury an HVED cable system more deeply in locations where there is utility congestion. Conversely, HVED splices and terminations are simpler to construct.

For this application, an HVED cable system is less complex, less costly, requires less time to repair, and is easier to maintain post-energization than an HPPT cable system. Furthermore, there is only one remaining manufacturer of HPPT cable, leaving the Applicant at risk if issues were to arise with that manufacturer pre- and post-energization. The Applicant, and the underground transmission industry in general, are moving towards newer technologies that have no risk of fluid leaks, have lower environmental impact, less maintenance, and lower cost. In addition, the Applicant recently has successfully installed many HVED systems across their service territory. For these reasons, HVED cable was chosen as the preferred cable technology for the Project.

E-3.2 SYSTEM DESIGN STANDARDS FOR MICRON FABRICATION AREAS

The Project to provide electric service to Micron will consist of eight 345kV circuits, where each circuit will need three 345 kV HVED insulated power cables. Each circuit will be placed in its own duct bank that will include four 8-inch power cable ducts (three ducts for power cable, one duct spare). The nominal trench excavation for the duct bank will be up to 4 feet wide and 5 to 8 feet deep or more depending on site conditions. The duct bank will contain a total of seven conduits: four 8-inch diameter conduits for the 345 kV cables, two 4-inch diameter conduits for a relay and communication cables, and one 2-inch diameter conduit for a ground conductor. The conduits will be encased in a concrete duct bank.

In general, the standards for installation of the cable system involve three major stages:

1. Manhole installation;
2. Trench excavation, duct bank installation and pavement patching;
3. Cable pulling, splicing, and testing

E-3.2.1 Manhole Installation

Precast concrete manholes will be placed approximately every 1,500 to 2,500 feet along the route. Factors contributing to the distance between manholes include allowable pulling tensions, sidewall bearing pressure on the cable as it goes around a bend, the maximum length of cable that can be transported on a reel based on the reel's width, height, and weight, and the allowable voltage rise on the cable shield. Manholes are typically installed in a sequential schedule; each manhole will take approximately one week to install. At each manhole installation, a 4-foot by 4-foot handhole to house the communications cable will be put in simultaneously in close proximity to the manhole.

Manholes facilitate cable installation and splicing and allow access for maintenance and future repairs. The manhole dimension is determined by the space required for cable pulling, splicing, and supporting the cable in the manhole. For this Project, each manhole will be approximately 8-feet wide by 33-feet long and 8-feet high. The manhole depth will vary by location with the manhole base being approximately 10 to 12 feet below grade. The manholes will be located entirely underground; the only visible aspects at ground level will be the manhole covers.

National Grid will implement appropriate best management practices ("BMPs") for the control of erosion and sedimentation from the work site during excavation activities associated with the manhole installation as set forth in the Environmental Management & Construction Plan ("EM&CP") and its Stormwater Pollution Prevention Plan ("SWPPP"). Regular inspections will be undertaken to ensure control mechanisms are maintained.

E-3.2.2 Trench Excavation, Duct Bank Installation, and Pavement Patching

The underground duct bank utilized in Segment 1 and Segment 3 for the Project will be installed using open-cut trenching. For each segment of the route, Dig-Safe will be contacted, the location of existing utilities will be marked, the width of the trench will be marked, and the trench will be excavated by excavator/backhoe. For the crossing of Caughdenoy Road, if open-cut trenching is utilized, the width of the trench will be marked on the street, and the pavement will be saw cut. Following saw cutting, the existing pavement will be removed using mechanical means and sent for recycling to an approved facility. Pavement will be handled separately from the soil because the pavement will be recycled at an approved facility.

The trench will be excavated to the required depth by excavator/backhoe. In some areas, part of the excavation will be done by hand or vacuum excavation methods to avoid disturbing existing utility lines and/or service connections. Topsoil and organics will be segregated from subsoils and stockpiled for reuse when backfilling the trench. Any rock encountered during excavation will be removed by mechanical means. Shallow bedrock may be removed by drilling holes in the rock to allow hydraulic breaking. No blasting will occur to remove the rock. Excess soil will be disposed of in a DPS Staff approved manner, to be outlined within the EM&CP.

The trench will be sheeted and shored as required by soil conditions and Occupational Safety and Health Administration ("OSHA") safety rules. Under the typical conditions known for this area, it is anticipated excavation and shoring will proceed at roughly 40 feet to 100 feet per day. If significant amounts of shallow bedrock are encountered, the rate is likely to slow to approximately 40 feet or less per day. Once a portion of the trench is excavated, the PVC conduit will be assembled and lowered into the trench.

The area immediately around the conduits will be filled with high strength thermal concrete to protect the conduits, the trench backfilled, and the surface restored. Backfill materials may consist of thermal concrete and/or controlled native or non-native backfill, to be outlined within the EM&CP. The diagram in Exhibit 5, Figure 5-1 illustrates a typical duct bank cross section in a two by two or "square" configuration

During the trenching and duct bank construction, National Grid will make every reasonable effort to maintain access to adjacent streets or businesses. At various points in the trenching and duct bank construction process, it will be necessary to have an open trench that may temporarily impede access, but once the crews are finished, the trench will be steel-plated to re-establish access to Caughdenoy Road. At the end of each workday, any remaining open trenches will be covered with securely anchored steel plates of sufficient thickness to withstand traffic loading.

E-3.2.3 Trenchless Crossings

Specialized civil construction methods, such as conventional bore are required to cross under the Buckeye Pipeline ("Buckeye") and the CSX rail line and may be required for the crossing of Caughdenoy Road. Open-cut trenching across the CSX rail line is not permissible due to the unavailability of the rail line for an extended period of time.

The conventional bore to cross under Buckeye and the CSX rail line will involve excavating pits on both sides of the crossing. The bore pit is configured with a mechanical ram that advances the casing while an auger removes spoils from the face of the excavation; spoils from the face of the boring are brought back through the casing and removed. Casing segments are subsequently added as the bore hole is advanced until the casing reaches the receiving pit. Exhibit 5, Figure 5-2 shows an example of the bore pit.

After a bore is complete, conduits are pushed through the casing and will be joined with the conduits from the open-cut sections on either end of the boring. Each casing is then filled with a grout that is pumped through the casing.

Each circuit will require a bore casing totaling eight (8) conventional bores to cross under the CSX rail line.

E-3.2.4 Cable Installation

Following the installation of the manholes and duct bank as described above, the cable will be pulled through the conduit. Prior to the installation of the cable, the conduit will be tested and cleaned by pulling through a swab and mandrel (a close-fitting cylinder designed to test a conduit’s shape and size). When the swab and mandrel have been pulled successfully, the conduit is ready for installation of the cable.

Three 345 kV cables will be installed between two adjacent manholes. To install each cable section, a cable reel will be set up at the “pull-in” manhole and a cable puller will be set up at the “pull-out” manhole. A pulling line will be pulled through each duct; then a hydraulic cable pulling winch and tensioner will be used to individually pull cable from the pull-in to the pull-out manhole. Installation of cable sections between two manholes will typically take two to three 8-hour days. This process will be repeated until all the cable sections are installed.

Once adjacent cable sections are installed, they will be spliced together in the manholes. Splicing HVED transmission cable is a time-consuming, complex operation. It typically requires 40 to 60 hours to complete the splicing of all three cables at each manhole. The splicing activities will not be continuous but will take place over four or five extended work days at each manhole location. The splicing operation requires a splicing van and a generator. The splicing van contains all the equipment and material to make a complete splice. At times, an air conditioning unit will be used to control the moisture content inside the manhole. A portable generator will provide the electrical power for the splicing van, circulation fans and the air conditioning unit. The generator will be muffled to minimize noise.

Typically, the splicing van will be located at one manhole access cover. The ventilation fans and air conditioner will be located near the second manhole access cover and the generator will be in a convenient area that does not restrict traffic movement around the work zone.

In addition to the three 345 kV cables, a ground conductor will be installed between manholes and communication cables will be installed between handholes in a manner similar to pulling the 345 kV cables.

The ground conductor will be spliced at the same time the 345 kV are spliced. The communication cables will require a separate splicing operation with a small splicing van at each handhole location for one day.

Once the complete cable system for each Fab area is installed, and upon completion of its respective Fab area substation, it will be field-tested from the substations. At the completion of successful testing, the cables will be energized.

E-3.3 CABLE SYSTEM DETAILS

E-3.3.1 Number and Size of Conductors to be Used

The number, size, and additional details regarding the nature of transmission conductors to be used are detailed in Exhibit E-1: Proposed Transmission Facilities.

E-3.3.2 Depth of Cable

The depth of cable, as well as additional details provided by the profile of the circuits, are detailed in Exhibit E-1: Proposed Transmission Facilities. Proposed depths of cable installations can be found on the design drawings located within Exhibit 5, Figure 5-3.

E-3.3.3 Location of Oil Pumping Stations

There are no proposed oil pumping stations, as detailed in Exhibit E-1: Proposed Transmission Facilities. HVED cable systems incorporate three conductors, each insulated with an extruded plastic material such as cross-link polyethylene (also referred to as XLPE). This type of system differs from high pressure pipe-type ("HPPT") systems that use dielectric fluid for insulation. HPPT systems require a pressurization plant to maintain the dielectric fluid pressure at approximately 200 pounds per square inch ("psi"), which in turn is not needed with an HVED system due to the insulation being made of XLPE materials.

E-3.3.4 Location of Manholes

In preliminary design, the location of underground manholes can be located on Figure 5-4 in Exhibit 5. Exact locations of manholes have not been finalized. This information will be contained in the EM&CP. The Micron underground transmission circuits have the quantity of manholes listed below:

- Line 33/Line 44 serving Fab 1 – One (1) manhole each
- Line 55/Line 66 Serving Fab 2 – Two (2) manholes each
- Line 77/Line 88 Serving Fab 3 – Three (3) manholes each
- Line 99/Line 111 serving Fab 4 – Five (5) manholes each

As noted above, manholes will be placed along the route in which cable sections are spliced together that are approximately 8ft x 33ft x 8ft. The typical installation pulling section lengths for transmission XLPE cables is 1,500-3,000 feet based on what can be shipped in a standard reel and maximum allowable pulling tensions for plastic jacketed cables in plastic ducts. This Micron underground transmission project will require multiple installation sections with intermediate splices. The lengths of installation sections are determined based on lengths of cable that can be transported to the site and so that pulling tension limits are not exceeded.

Since this Micron underground transmission project has multiple circuits, each circuit will have its dedicated manhole for each set of three phase cables so that work can be done on one set of cables in the manhole while others remain energized without workers present. Additional "pull-through" manholes could be located near the terminals to more rapidly facilitate a termination repair.