CONSIDERATIONS FOR HORIZONTAL DIRECTIONAL DRILLING/BORING

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2.0 PURPOSE

This standard is to provide 'insight' and 'considerations' to assist the engineer and planner in regards to installing conduit by 'horizontal directional drilling/boring' requirements.

3.0 GENERAL

3.1 There are three approved construction techniques for NVE underground cable installation:
a. Open-cut trenching w/ "stick pvc" conduit.
b. Plowing in "Cable in Conduit".
c. Directional drilling / boring with various type conduits. See CAB12U, Vol. 5, for plowing.

3.2 Guided boring and horizontal directional drilling techniques are used for the trenchless installation of new conduit(s). The drill path may be straight or gradually curved, and the direction of the drilling head can be adjusted at any stage during the bore to steer around obstacles or under highways, rivers or railways. Drilling can be carried out between pre-excavated launch and reception pits, or from the surface by setting the machine to drill into the ground at a shallow angle.

3.3 Equipment capabilities have improved over the years, and the advantages of trenchless technology for new construction have become more widely appreciated. Some city / counties may now have a presumption against open-cut techniques (particularly in roads) where a 'no-dig' alternative is available. Apart from the obvious environmental benefits of trenchless installation, the relative cost of guided boring has fallen to below that of trenching for many applications, even ignoring the social costs of traffic disruption and delay.

3.4 Guided boring or directional drilling can be used for the trenchless (or minimum excavation) installation of conduits in most diameters and over distances of up to a mile.

3.5 Both surface-launched and pit-launched drilling machines are available, the choice depending on the nature of the project.

3.6 Machines range from compact rigs suitable for small bores and operation in restricted spaces, to extremely large units designed for large diameter, long distance crossings.

3.7 Most guided boring machines use a drilling fluid which lubricates and stabilizes the bore, and also conveys the excavated material in suspension. Some rigs are, however, designed for dry operation, and may offer benefits depending on the bore diameter and the ground conditions.

3.8 The formulation of the drilling fluid or ‘mud’ is important, especially in difficult soils, and advice should be sought from specialists where necessary.

3.9 The choice of guidance system depends on the type of machine and also whether access is available for ‘walk over’ tracking. Radio, hard wire and magnetic systems are available.

3.10 Primary cables for NVE's local loops and mainline feeders are 1/0, 350kcm and 1000kcm Al. 1/C TRXLP (15kv, 175mil and 25kv, 260mil) with jacketed concentric neutral in a conventional 'PVC stick' conduit system. Refer to CAB01U, Volume 5, for detailed primary cable data. The following will cover the details to facilitate conduit installation via *directional boring.*

3.11 *As soon as you know about the possibility of a horizontal directional boring project call a contractor and discuss with him: location, scale of the project, conduit size and type required, lead times, site setup, length of bore, price, etc.*

4.0 ENGINEERING AND CONTRACT LAYOUT

How a complete project or single bore is originally engineered is affected by actual site conditions including soil formations, terrain, existing utilities, and setup constraints. The length and final outcome of the bore may differ from the original design subject to the limitations of downhole tooling and drilling conditions encountered. This can result in dollar discrepancies for both the NVE and the contractor. Pre-planning and evaluation by the NVE engineer, inspector, and contractor are keys to successfully minimize potential conflicts about work performed and price issues. When possible, thorough on-site evaluation and contingency planning are strongly recommended. *Consideration must be given to the following commonly misunderstood factors affecting drilling outcome and price:*

Single lump sum or unit prices: Many bid packages request a single unit price for a diversity of drills. It is critical that contracts differentiate between projects requiring different sized rigs. Other issues such as soil conditions may vary between bores thus affecting production rates and costs. *Clearly spelling out unit prices and including add/delete clauses are strongly recommended.*

Access: NVE should obtain access from local property owners prior to construction. It is not practical for the contractor to accurately price access agreements at the time of the bid. NVE will be obtaining right-of-way agreements and therefore have a long-term relationship with individual property owners. It is in NVE's best interest that access agreements be made in a professional and timely manner.

Soil conditions: The ground conditions greatly affect penetration rates, downhole tool selection and other issues regarding the contractor's price. It is therefore in NVE's best interest to provide soils information as a basis for the contract price. This will ensure that bids are comparable. However, the contract should also allow price changes for differing or unforeseen soil conditions. Core samples and borings supplied by the NVE engineer prior to bidding would enable the contractor to prepare a more accurate and competitive bid.

Drill pipe limitations and rig setup: Special consideration must be given to the limitations of the drill pipe. Rig setup can be affected by a number of environmental logistical concerns.

Installation limitations— Steel pipe, HDPE, Carlon's Bore-guard and PVC rigid stick conduits are affected by a combination of stress factors including pulling forces, profile of the bore, bend radius of the pipe as it enters the ground, and stress from overburden and external hydrostatic stress. Depending on the size of the plastic or steel conduit , it simply may yield to the stresses and result in weakened or broken welds. HDPE conduit is subject to collapse or stretched to a flattened and unusable condition. See Section 10.0.

Existing utilities and subsurface obstacles: These items affect the bore design and planned depth. For example, bid specifications may call for a minimum depth of installation at 48" but consideration must be given to existing utilities. A majority of city utilities including gas, water, and power are at a 36" to 48" depth. In order to maintain specified clearances and minimum depth requirements, the new product installation must usually be drilled at depths of 60" or more. Depths of 1' to 10' are within the typical installation considering sewer and storm drainage lines. This results in longer bores to accommodate greater depths. All potentially affected utilities should be contacted prior to commencing work.

Failed bore path: Self-explanatory. Regroup and try another location.

Linear footage versus actual bore footage: *Discrepancies between actual bored footage and linear footage are the norm.* The bid package needs to specify how footage will be paid and the contractor must adjust bidding practices accordingly. Footages should be mutually agreed upon immediately at completion of the bore.

Conduit acceptance: The conduit will be mandrelled and a pull line provided in accordance with CD0001U, Vol. 17, Sections 19.0 and 20.0.

Environmental concerns: The contract should address environmental concerns because all parties are potentially responsible. Federal, state and local laws must be evaluated and regulations must be followed. Drilling fluid and cuttings disposal are difficult to price, and it is recommended that it be priced on a unit basis rather than lump sum.

Safety Requirements: No written procedure can cover every situation that might arise in the field. However, with careful planning and following the contractors approved written guidelines, most safety-sensitive problems can be eliminated or at the very least minimized. The Contractor must provide these guidelines for NVE review.

Dispute Resolution: All contracts should have equitable provisions for termination, indemnification, and payment terms. It is highly recommended that the contract incorporate Alternative Dispute Resolution such as arbitration or mediation.

Contractual Issues: As in any construction project, a detailed written agreement must be used that both parties completely understand. The contract should provide workable mechanisms for changes in the work so that timely adjustments can be made while construction is underway. In particular, the contract should address all the items mentioned in this guide plus many more.

5.0 WORKING SPACE AND SET UP

5.1 Ideally every bore site would allow for a minimum 50' x 100' work space. This is rarely possible, especially in urban areas. Due to restrictions placed on lane closures or the necessity to work in tight alleyways, sidewalk rights of way, landscaped areas, or specified utility corridors, equipment often must be configured in a linear pattern taking up no more than a single lane of traffic.

5.2 Other work space considerations include the presence of overhead utilities which may interfere with operation of the boom or mast and underground utilities which may impact the actual running line of the proposed installation and setup of the drilling rig. Restricted work hours that allow for peak travel times will also impact the full use of a drill site.

5.3 The work space environment must also allow for the digging of entry, exit, and recirculating pits. Although directional drilling provides for the least disruptive environmental impact for NVE installation, property owners or governing entities must be informed that these pits are a necessary part of directional drilling operations.

5.4 Contract employees must remember that they are part of a team and that they are responsible for their own safety, as well as the safety of the team members. With everyone working together, a safe and healthy workplace can exist.

5.5 The work space will be clean and left with as little damage as possible.

6.0 MATERIAL STORAGE & HANDLING

6.1 Proper care and handling during installation is critical to the long term reliability of buried conduits.

6.2 ***Storage of Material/Equipment***: It is the **responsibility of the contractor** to ensure that all material and equipment to be used in the proposed construction be stored so as to be protected from deteriorating effects of the elements. If outdoor storage cannot be avoided, the material and equipment must be stacked on supports well above the ground line and protected from the elements as appropriate, and ***with due regard to public safety*.**

6.3 ***Handling of Conduit***: It is the **responsibility of the contractor** to ensure that the conduit shall be handled carefully at all times to avoid damage, and shall **not be dragged** across any sharp projections. Care shall be exercised to avoid excessive bending of the conduit. The **contractor** shall ensure that the ends of the conduit be sealed at all times against debris with suitable end caps. *Where it is necessary to cut the conduit, the ends will be terminated or sealed immediately after the cutting operation.*

7.0 DRILLING PROCEDURES

Drilling procedures consist of three phases: pilot hole, reaming, and pullback or conduit installation.

7.1 The *pilot hole* can be the most important phase of a project. It determines the ultimate position of the installed conduit. A small-diameter drill string penetrates the ground at the prescribed entry point at a predetermined angle routinely between 8-12 degrees. The drill string is then advanced joint by joint using the hydraulic action of fluid-assisted drilling, also referred to as jetting. In harder soil formations, a mud motor may be required to facilitate drilling operations. The end of the drill string has a bend or bias to give the directional control needed to follow the proposed drill path. At the completion of each joint, the location of the drill head is obtained by use of a walkover system or a wireline steering tool. It is recommended that readings be taken at least every 30'. More frequent readings may be required due to the presence of existing utilities and critical exit sites. This information is then plotted against the proposed design plan and profile to determine the direction the next joint will be drilled. Once the drill head surfaces at the exit point, a measurement can be made to determine if the actual exit is within allowable tolerances. If a portion of the bore is out of the given tolerance, the drill string can be pulled back and this segment of the hole can be re-drilled. When the exit location is acceptable, the drill head and related tooling will be removed so reaming and pullback can commence.

7.2 *Reaming:* In certain-sized installations, the conduit can be pulled straight into the pilot hole after it is completed. However, in most installations the bore will require reaming to enlarge the hole to accommodate the installation of the proposed conduit. In general, the final bore should be at least 11/2 times the outside diameter of the proposed conduit. This is necessary to allow for an annular void for the return of drilling fluids and spoils and to allow for the bend radius of the proposed conduit. This rule of thumb is subject to soil conditions and proposed conduit. Depending on the size of the desired final hole and the soil conditions, reaming may consist of one or more passes.

There are a variety of different reamers for each soil type. A blade reamer is used for soft soils, a barrel reamer for mixed soils, and a rock reamer with tungsten carbide inserts is used for rock formations. The type of reamer and existing soil condition will directly affect the speed of the reaming operation. Matching the right reamer for the existing soil conditions and the correct amount of drilling fluid pumped downhole is critical to the process and can save money and time.

7.3 *Pullback*: Once the drilled hole is enlarged, the proposed conduit can be pulled back into the reamed hole filled with drilling fluid. The conduit that has been fabricated (preferably in one section) and tested on the exit side can now be readied for pullback. If the product is steel, it is recommended that the steel pipe be placed on rollers to reduce friction and to protect any pipe coating. This procedure is usually not required for PVC stick or HDPE conduit installations. The drill pipe is connected to the conduit using a pullhead or pulling eye and a swivel. The swivel is used to prevent rotational torque from spinning the conduit. A reamer is also placed between the pullhead and the drill string to ensure that the hole remains open and to allow more lubricating fluid to be pumped into the hole during the pullback. The pullback operation will continue until the conduit surfaces at the drill rig. The pullhead can then be disconnected, the drill rig removed, and cleanup and tie-ins started.

7.4 The **contractor is responsible** for locating other existing buried utilities.

7.5 The conduit must be inspected carefully as it is paid out from the reel to be certain that it is free from visible defects. Every instance of damaged conduit observed at any time, whether prior to installation, or during installation shall be immediately called to the attention of NVE. Repair or correction of such damage must be completed promptly and in accordance with the written instruction of NVE. The location of any such repair must be indicated on the staking sheet.

8.0 SPECIAL REQUIREMENTS

8.1 There are many special coordination requirements between NVE and the contractor when conduits are to be installed by *HDD.*

8.2 It is the **responsibility of the Contractor and NVE to jointly review the staking sheets** prior to the start of construction. At that time, the Contractor shall propose any desirable changes or clarifications. These changes, if approved by NVE, shall be made and recorded on the staking sheets. No changes on the staking sheets shall be made by the Contractor without the prior written approval NVE. A representative of NVE shall remain in the immediate vicinity of the HDD operations at all times and shall consider and possibly approve any acceptable changes proposed by the Contractor.

A NVE representative shall also inspect any damage to conduit and approve acceptable methods of repair or correction of such damage in accordance with the provisions of the W.O. specifications.

8.3 In the event that rock is encountered during the plowing operation so that the buried cable can not be installed to the required minimum depths, the **Contractor** shall determine for NVE the nature and extent of the rock encountered. Based on this information, NVE shall determine whether the cable is to be rerouted, trenched in rock or a change made to aerial construction. This decision shall be made promptly, and appropriate changes in units shall be made on the staking sheets. Such changes shall be in writing, dated, and initialed by NVE.

8.4 Due to the necessity of making on-the-spot corrections and changes on staking sheets, it may not be possible for NVE to issue revised staking sheets to the Contractor in all cases. When changes are made, dated, and initialed by NVE on a set of the Contractor's staking sheets, it shall be the **Contractor's responsibility** to transfer these changes to all other sets of staking sheets being used by the Contractor for construction purposes.

8.5 **The Contractor shall provide a competent representative to work with NVE** on the inventory and inspection of the installed conduit. The inventory of installed conduit will be made as soon after the HDD operation as practical to avoid later disagreements on the quantity of conduit installed when changes are required in the project.

8.6 *Documentation of changes and 'as-built' will be provided by the contractor*.

9.0 POT HOLING/TRENCHING

If any pot-holing or trenching is required, it is the **responsibility of the HDD contractor** to ensure that all depths specified are minimum as measured from the final grade to the top surface of the conduit. The routing must be as shown on the staking sheets and plans and specifications unless conditions encountered are such that changes are necessary to accomplish the work. In such event, NVE shall be notified promptly. If rock or other difficult digging is involved, the Contractor shall determine the nature and extent of the difficulty, and NVE shall determine whether rerouting, rock trenching, plowing or other changes are necessary.

10.0 MINIMUM BENDING RADIUS OF CONDUIT

It is the **responsibility of the HDD contractor** to ensure that the minimum bending radius of conduit is *greater than that recommend by the conduit manufacturer*. Drilling rod typically has a recommended bend radius of 1200 x OD and the bending radius of conduit is generally a minimum of 100 x OD. In all cases the minimum radius specified is measured to the surface of the conduit on the inside of the bend.

11.0 TAGGING OF CONDUITS AT TERMINATION POINTS

11.1 All conduit shall be neatly trained with *gradual 90 degree* bends to their destinations in splice vaults.

11.2 As the conduits are pulled in, it is the **responsibility of the contractor** to ensure that they be identified and tagged. The identification must be of a permanent type, such as that done with on plastic or corrosion resistant metal tags. The tag must be securely attached to the conduit. Paper or cloth tags are not acceptable.

12.0 CONDUIT LOCATION MARKERS

It is the **responsibility of the contractor** to ensure that location of permanent conduit markers shall be as shown on the W.O. sheets.